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MAYFLIES OF PUERTO RICO

JAY R. TRAVER

The mayfly fauna of this island has not been studied, up to the present time. There seem to be but two references to a specimen of this order from Puerto Rico, in the published literature of the group. The first of these may be found in Dr. Hagen's *Synopsis*, (9) pg. 54, under *Cloe unicolor* Hagen: "I have seen a female specimen from Puerto Rico, similar to this, with the thorax fulvo-aeneous: is it a different species?" The second reference occurs in Kolbe's (13) *Die geographische Verbreitung der Neuropteren und Pseudoneuropteren der Antillen*, pg. 172: "II. Ephemerida, Von dieser Abtheilung liegt nur ein verdorbenes Exemplar vor, welches vielleicht eine Spezies von Calibaetis ist."

During the spring of 1935, Prof. James G. Needham of Cornell University, and Dean García-Díaz of the University of Puerto Rico, collected many mayfly nymphs and imagos on the island. Later, in the summer of 1935, Dean García-Díaz made many further collections and reared many specimens from nymphs. As a result of this work, twenty species of mayflies, representing six genera in three subfamilies, have been found to inhabit Puerto Rico. An account of these twenty species is herewith presented; three new genera and nine new species are described, along with keys for the determination of imagos and nymphs, and notes on several unnamed species. The designation of the wing veins is that of Tillyard, 1923 (18) and Needham, Traver, Hsu, 1935 (17).

SUBFAMILY LEPTOPHLEBIINAE

Two new genera of this subfamily are considered to be present in the material from Puerto Rico, each represented by two or more species. Both genera are allied to Hagenulus,—one of these may, in fact, be the true Hagenulus. Since, however, the nymph of Hagenulus is not known, and males of the Antillean species (including

the type species) are unknown or known incompletely, it is considered better to discuss the two Puerto Rican genera under new generic names.

Discussion of the genus Hagenulus and allied forms

The genus Hagenulus Eaton (1882) (4), type *caligatus* Etn., from Cuba, was described from female imagos and a male subimago. Genitalia of the male, and wings (presumably of female) are figured, in the Revisional Monograph (5). Wings of the female have distinctly margined cross veins; outer fork of radial sector normal,—i. e., with no tendency to sag toward the rear margin; penes of male are straight. rod-like, structures, divided near the base, wholly without spines or bristles. A note following the original description states that four male imagos, "of, perhaps, another species", differing from the male subimago of *caligatus* in numbers of cross veins in costal space, are present in the Hagen collection, from Cuba. These males have spotless wings. In the Revisional Monograph, it is stated that these specimens are females. Dr. Banks (1) says that these four specimens are males, and thinks they may be *caligatus*. Another Antillean species of this genus, *H. eatoni* Bks. (1), from Haiti, is known from females only. In these, the fore wings are similar to those of *caligatus* Etn., but the hind wing differs somewhat in shape. Three other species have been described in Hagenulus: *monstratus* Etn., (8) from Bermuda; *scotti* Etn., (7) from Seychelles; and *turbinatus* Ulm., (22) from East Africa. Hind wings are figured for two of these species, genitalia for one of them. In two of these (*scotti* Etn. and *turbinatus* Ulm.) the wings of both sexes are wholly lacking in darkened cross veins, but in *monstratus* Etn., dark-margined veins are present in both male and female. The hind wings are not typical of Hagenulus as represented by *coligatus,* in the two species figured. Nymphs of all five of these species are unknown.

Peculiar Leptophlebiine nymphs taken in Cuba (C. F. Baker, J. G. Needham) were described by Mrs. Emily R. Morrison (15) as Hagenulus. Cross veins in wing-pads of female nymphs are dark-margined; those of the males have a few spots only. The hind wing somewhat resembles Hagenulus. Mouthparts of the nymphs are peculiar, in that the labrum is much wider than the head. Gills filamentous, each pair bifurcate, the divisions unequal in size. Genitalia removed from a mature male nymph are seen to possess distinct inwardly-directed spines on the penes, much as in Neohagenulus. Are these the nymphs of the genus Hagenulus? If so,

the presence of spines on the penes must be a specific character. Wing-pads of female nymphs are normal as to the outer fork of the radial sector; in the males, however, there is a slight rearward sag in this fork. Other nymphs, taken in Jamaica by Prof. E. L. Palmer of Cornell University, resemble those of Neohagenulus in mouth-parts and structure of gills. The wing-pads of the females are dark-spotted, those of the males are spotless. Outer fork of radial sector normal in females, slightly sagged in males.

Nymphs of the two Puerto Rican genera have been reared, and both sexes are represented. Until *Hagenulus caligatus* Etn. has been reared from nymphs, and males and females correctly associated, so that the type of the genus may be fully known in its several stages, the Puerto Rican forms are held under the names Neohagenulus and Borinquena (new generic names). The differences in the gills of the nymphs seem to indicate clearly that two genera are involved.

Under the genus Borinquena are placed two species, apparently rather closely allied except in the form of the hind wing. In *B. contradicens* n. sp., the hind wing is like that of *Hagenulus caligatus,* but genitalia resemble *B. carmencita* n. sp., the genotype. Thus *B. contradicens* has characters of Borinquena and also of Hagenulus. It is tentatively placed in Borinquena, because of the type of the male genitalia and the gills of the nymph. By structure of hind wing and presence of ovipositor in the female, it would fall into Hagenulus. Gills of nymph filamentous, single, in both species. In fore wing of male as well as of female, the outer fork is distinctly sagged to rearward. No dark-margined cross veins, in either sex.

The three species placed in Neohagenulus resemble one another quite closely. Gills of nymphs filamentous, bifurcate, the two parts of each unequal in size and length. Genitalia somewhat as figured by Eaton for *H. caligatus,* but with distinct spines on the penes. Hind wing reduced in size, but not quite like that of *H. caligatus.* No true ovipositor present, in female. Outer fork of radial sector in wing of male distinctly sagged, almost normal in female. No dark-margined cross veins, in either sex.

Key to Antillean Genera of Leptophlebiinae

ADULTS

1. Cross veins of fore wing of female dark-margined; no spine-like processes on penes, which are slender and rod-like; long ovipositor present__*Hagenulus*
   Cross veins in fore wing of both sexes without dark margins; a pair of short, spine-like, processes present on penes; ovipositor present or absent____ 2

2. Outer fork of radial sector in fore wing distinctly sagged to rearward, in both sexes; female with very long ovipositor; long joint of forceps of male almost straight -- *Borinquena*
   Outer fork of radial sector in fore wing almost normal in female, distinctly sagged in male; no true ovipositor present; long joint of forceps of male strongly bowed -- *Neohagenulus*

NYMPHS

1. Gills single, each a slender filament -- *Borinquena*
   Gills double, filaments of each pair unequal -- 2
2. Labrum greatly extended laterally, being wider than head; outer margin of mandible angulate at postero-lateral angle ---------- ? *Hagenulus* (Cuba)
   Labrum only slightly wider than clypeus, about one-half the width of the head; outer margin of mandible rounded, convex -- 3
3. Wing-pads of female nymph dark-spotted -- Jamaican species
   Wing-pads of both sexes with no dark spots -- *Neohagenulus*

Genus **Neohagenulus** gen. nov.

Small dark-colored mayflies. Eyes of male very large, contiguous apically, almost concealing the pronotum. Median ocellus much smaller than the laterals. Posterior margin of head of female slightly emarginate. Posterior margin of pronotum excavated in median area. Fore leg of male slightly shorter than the body. Femur slightly more than half as long as tibia; tarsus about ¾ the length of the tibia. Basal fore tarsal joint very short; 2nd joint longest, other joints progressively shorter, the fourth about ½ the length of the 2nd. Fore femur of female ⅞ as long as tibia; tarsus about ½ the length of the tibia; distal tarsal joint the longest. In hind leg of both sexes, the four basal tarsal joints are subequal; distal joint about as long as any two of the preceding; in male, somewhat longer than in female. Claws dissimilar on all tarsi.

Fore wing as shown in figure 1. Basal cross veins of costal and subcostal spaces faint; stigmatic cross veins well developed, somewhat aslant. Outer fork of radial sector in fore wing of male distinctly sagged to rearward (less distinctly so in female). Cubital intercalary and first anal veins united at base. Hind wing much reduced in size (fig. 11); drawn out into a sharp point at apex, but this point not bent over. Two well-developed longitudinal veins in wing of male, three in female; behind these, two or three others, faint and incomplete. Several faint cross veins; one at apex well developed.

Forceps three-jointed; long basal joint swollen in proximal half. Forceps base entire. Penes somewhat rod-like; each bears a forward-projecting spine, about ⅓ of the distance from the apex (fig. 3). Apical margin of subanal plate of female with a deep V-shaped cleft. A short egg valve, not a true ovipositor, is borne on the seventh sternite, as shown in figure 7.

Body form of nymph reminiscent of Choroterpes, and very similar to that of Borinquena. Mouthparts as in Borinquena, except that distal joint of labial palp is shorter (figs. 48, 49). Rather long spines on posterior margins of femora; numerous spines on hind tibia, rather generally distributed (figs. 14, 16). Claws pectinate (fig. 46). Short postero-lateral spines on abdominal seg-

ments 3–9; very short on 3–6, longest on 9. Gills double, filamentous; the inner member of each pair is more slender and slightly shorter than the outer one. Each filament contains a single main trachea, often with minute, lateral, branches (fig. 18). Tails three, considerably longer than the body; middle tail longer and slightly stouter than the laterals.

Genotype—**Neohagenulus julio** sp. nov.

Key to Species of Neohagenulus

ADULTS

1. Wings of both sexes distinctly brown-tinged throughout; cross veins prominent ---------- *tinctus*
   Wings not distinctly brown-tinged throughout; cross veins less prominent, except along costal margin ---------- 2
2. Longitudinal veins in wing of male yellowish along costal margin, elsewhere paler; costal band in wing of female rather dark red-brown ---------- *luteolus*
   Longitudinal veins, also cross veins of costal area and apical third of wing, brown; costal band in wing of female pale brown, usually paler toward apex ---------- *julio*

NYMPHS

1. Pale areas on head between eyes and ocelli distinctly divided by a greyish black line; spines on fore femur and on hind tibia relatively short (see figs. 15, 17) ---------- *luteolus*
   Pale areas on head between eyes and ocelli not divided by a dark line; spines on fore femur and hind tibia longer (see figs. 14, 16) ---------- 2
2. Second joint of antenna pale; ventral markings, when present, usually confined to lateral part of posterior margins of sternites ---------- 3
   Second joint of antenna blackish, at least in apical half; ventral markings more extensive ---------- 4
3. Ventral markings usually absent; abdominal tergites of female largely yellowish ---------- *sp. No. 2*
   Ventral markings usually present; abdominal tergites of female largely reddish brown ---------- *julio*
4. Body (female) 7 to 8 mm. in length ---------- *sp. No. 1*
   Body (female) 6–6½ mm. in length ---------- *tinctus*

Neohagenulus julio sp. nov.

A dark brown species, having middle and hind legs pale; entire wing *not* distinctly brown-tinged.

Male imago.—Body 5–6 mm.; wing 5½–6 mm.

Head dark red-brown, (see fig. 21, lateral aspect). Lateral ocelli pearly white, deep red-brown at base. Black, transverse, line along frontal margin; black markings around bases of antennae, between antennae and eyes, on frontal carina and below antennae. Upper portion of compound eyes deep red-brown, lower portion blackish. Thorax dark red-brown; mesonotum and sternum somewhat brighter than pleura and pronotum. Pronotum dark-margined; postero-

lateral angle with heavy black shading; a longitudinal, black, streak, on each side between median line and lateral margin. Mesonotal scutellum blackish; transverse sutures pale reddish, likewise median area directly anterior to scutellum; median area of anterior and middle portion intermediate in color between sutures and remainder of segment. Anterior to wing roots, a wide, whitish, streak margined with black; below wings, another whitish area with dark margins below and to rearward. Dark streaks above coxae on each side. Fore femur reddish brown; black at apex, deep red-brown median streak, black line along each margin. Tibia yellowish, tinged with reddish brown; deep smoky pre-apical area; lower margin blackish. Tarsus pale smoky. Middle and hind legs yellowish; black, apical, band on each femur; dark line along margin of each tibia; apical margin of tibiae tinged with pale smoky. Wings hyaline; very faint brownish tinge along costal margin. Venation deep red-brown. 6 or 7 strong stigmatic cross veins, distinctly aslant; other costal cross veins weak. All veins and cross veins in apical angle of wing heavier than elsewhere. Costa, subcosta and radius margined with dark brown at base; brown shading around bases of other main veins. Hind wing outlined in dark brown. Basal portion of costal margin and of the two main longitudinal veins dark brown. Wings as in figures 1 and 11.

Abdomen blackish brown dorsally, somewhat paler ventrally. Posterior margins of all segments narrowly black. A hyaline whitish dorsal patch on each of tergites 3–8, larger on apical than on basal segments; traces of a black, median, geminate, line on each pale area. A black, longitudinal, streak, usually interrupted, lies halfway between median line and lateral margin; laterad of this, another small, hyaline, whitish, spot, near anterior margin in basal tergites, but lengthened into a pale streak on tergites 6–8; on 8, this streak and the pale, dorsal, patch are confluent posteriorly. Tergites 9 and 10 red-brown like thorax. Hyaline areas on sternites next to pleural fold in antero-lateral angle, and along anterior margins. From the latter area short, irregular, pale, triangles may extend backward into the darker portions of the sternites; anterior half of median line likewise hyaline. Forceps base, penes, and basal joint of forceps reddish brown; distal portion of forceps pale (fig. 3). Basal forceps joint widened at base, suddenly narrowed and bowed near the middle of its length, much as in Choroterpes. Genitalia as in figure 3. A long, slender, spine seems to be present on inner margin of penes (fig. 44). Tails pale, the segments irregularly tinged with smoky; joinings purplish black, alternately wide and narrow.

Female imago.—Body 5–5½ mm.; wing 5–6 mm.

Head very light reddish brown. Dark markings as in male; also a wide, black, band across head between ocelli, another back of ocelli along posterior margin; usually two small, pale, submedian, spots on posterior margin. Basal joints of antennae smoky. Pronotum concolorous with head; wide, black, margins, and a triangular black mark on each side of median line. Mesonotum darker red-brown; scutellum and median line directly anterior to it, blackish. Pleura and sternum largely yellow, the former tinged with red-brown, and marked with black as in male. Legs much as in male; a longitudinal, black, hair-line on each, from coxa to tip of femur. Entire costal space in fore wing very light red-brown, hyaline; wing may be slightly tinged with brown elsewhere. Outer fork of radial sector much less distinctly sagged than that of male; venation deeper in color and more conspicuous. Abdominal tergites with essentially

the same coloring and pattern as in male, but pale areas more or less completely suffused with reddish brown. Usually a pale, lateral, triangle, a narrow, median, line margined with black, and two small, submedian, marks on the anterior margins remain, in tergites 1–7. Pale areas more extensive on tergites 8–10. Sternites yellowish; posterior margins of all very narrowly darkened, that of sternite 1 most prominent. Sternites 2–7 marked as follows. Dark mark or streak in postero-lateral angle; dark line extends laterad of this toward median area, where it is conjoined to the posterior end of a dark submedian curved mark: ( ). Sternite 8 with dark shading around margin of the egg valve. Sternite 9 unmarked. Tails pale brownish; joinings as in male.

Nymph—Head reddish brown; small pale areas before median ocellus and at bases of antennae; a large, pale, area on each side, between eye and lateral ocellus. Vertex and occiput heavily shaded with blackish, leaving four pale, sub-median, spots, those nearer the posterior margin being larger. Antennae wholly pale. Pronotum yellowish; lateral margins and antero-lateral angles blackish. A trident-shaped, blackish, marking in median area, points of trident directed laterad and caudad. Mesonotum yellowish, shaded with black in antero-lateral area and above wing roots. Sternum yellowish. Legs yellow. Femora may be tinged with red-brown; narrow black line at apex of each, and black, longitudinal, hair-line basally on inner surface. Basal fourth of fore femur pale. Basal abdominal tergites of female nymph largely blackish brown; lateral margins yellowish, occasionally also the anterior portion of median line, and narrow, lateral, streaks. Tegrites 4–7 blackish brown, but with more extensive pale markings, located thus: median line (except at posterior margin) and areas on each side of it at anterior margin; oblique, lateral, streaks halfway from median line to pleural fold. Tergites 8–10 largely yellowish; posterior margin brown, likewise a wide, lateral, streak next to pale, outer, margin, and short, submedian, dashes at anterior margin. Posterior margins of all tergites darker. Male nymph has more extensive pale, median, areas on each tergite. Sternites yellowish, sometimes with faint red-brown tinge, most noticeable in male. Posterior margins narrowly darkened, in median area, but with wider and darker mark near lateral margin. Gills greyish, or with yellowish tinge; trachea and its minute branches black. Tails yellow; joinings opaque in young nymphs, red-brown in mature specimens. Tails of a partly-grown nymph are more than twice the length of the body, median tail longer than the laterals.

There seem to be no structural differences between this species and *N. tinctus,* so that it is difficult to distinguish the species represented, from the nymph slough. The slightly larger size and darker ventral markings of the nymph which is here treated as *tinctus*, plus the darkened second antennal joint, serve to distinguish the nymphs of *tinctus* and *julio*. Because of the size and ventral markings, it seems probable that the two species of nymphs treated as *tinctus* and *julio* have been correctly associated.

Holotype—Male imago. Río Cidra, Adjuntas, P. R., Mch. 24, 1935 (J. G. Needham, J. García-Díaz). No. 1398.1 in Cornell University collection.

Allotype—Female imago. Yunez River, P. R., June 21, 1935. No. 1398.2 in Cornell collection.

Paratypes—36 male imagos, 3 female imagos; Río Cidra, Adjuntas, P. R., Mch. 24, 1935; Luquillo Mts., P. R., Feb. 18, and June 9–14, 1935; Yunez River, P. R., June 21–22, 1935 (J. G. Needham, J. García-Díaz). Nos. 1398.3–41 in Cornell collection. Of these, four were reared from nymphs.

Other specimens of imagos were taken from the following localities, during 1935, by Dean García-Díaz. Lares, Guajataca Creek, Mch. 23; Luquillo Mts., June 7–14; Hicaco River, Mch. 7; Yunez River, June 21–22, and Aug. 12–15; El Yunque Trail, June 12, and July 27; Trout's Creek No. 1, June 9; and La Mina Recreational Area, July 14. Nymphs were ollected at Maricao, Mch. 23; Guaynabo River, Feb. 21; Hicaco River, Río Blanco, Mch. 7; Trout's Creek No. 1, June 9; Tallaboa Alta River, Feb. 25; Yunez River, Feb. 27; and El Yunque, Luquillo Mts., Feb. 18 and June 9.

Neohagenulus tinctus, sp. nov.

Distinguished from *N. julio* by the distinctly brown-tinged wings and more prominent cross veins.

Male imago.—Body 5–6 mm.; wing 5½–6 mm.

Head dark red-brown; black markings on frontal margin, at bases of antennae, and around ocelli. Upper part of eyes red-brown (in some of the paratypes, dark purplish brown). Ocelli milky white. Basal joint of antenna blackish at apex. Thorax dark red-brown. Pronotum, mesonotal scutellum, and pleura heavily shaded with black. A paler area anterior to wing roots, enclosed by black shading. Legs as in *N. julio;* however, the dark, apical band on each femur is narrower, less conspicuous. Fore wings distinctly, hind wings faintly, brown-tinged throughout; color slightly deeper in apical third of fore wing. All veins red-brown; those in costal margin of fore wing (costal, subcostal and next succeeding space) somewhat thickened. 8 to 9 stigmatic cross veins, very prominent, somewhat aslant; this area most deeply stained with brown. In holotype and most of the paratypes, all cross veins in fore wing distinct (in *julio,* those back of radial sector usually invisible).

Abdomen as in *N. julio.* In holotype, entire abdomen rather paler, dark bands on posterior margins of segments slightly wider; several of the paratypes are as dark as *julio,* the posterior bands not wider. Tails and genitalia as in *julio* (in both species, slight variations occur in shape of penes).

No apparent structural differences between this species and *N. julio* have been noted, either in the imago or the nymph. Thus, *tinctus* might be treated as a dark form of *julio.* The two species may bear much the same relation to one another as do *Blasturus cupidus* and *Blasturus nebulosus,* among the Nearctic members of this subfamily.

Female imago.—Body 5½–6 mm.; wing 5½–6¼ mm.

Very similar to *N. julio*. Wings distinctly brown tinged; costal band on fore wing red-brown, darker than in *julio*; cross veins somewhat more prominent. Abdominal tergites reddish brown rather than the blackish brown of *julio*. Thus, in the female of *julio*, thorax and abdomen are dissimilar in color, while in *tinctus* these areas are essentially similar. Apical tergites relatively lighter in color than in *julio*, in allotype and some of the paratypes. Abdominal sternites suffused with reddish brown, paler than tergites, but distinctly more reddish than same region in *julio*, thus showing less contrast between dorsum and venter. Dark markings of venter usually confined to the narrow, dark, posterior, margin of each sternite.

Nymph—Very similar to that of *N. julio*, with these differences. Second joint of antenna blackish (dark area confined to apical half of segment, in some specimens). Ventral abdominal markings more extensive; dark, posterior, margins of sternites wider and darker, often bordered by reddish brown shading; entire venter may be tinged with reddish brown. In some specimens, the gills have a faint reddish or purplish tinge.

Holotype—Male imago reared from nymph. Camp Lab. 48, Luquillo Mts., P. R., June 13, 1935 (J. García-Díaz). No. 1438.1 in Cornell University collection.

Allotype—Female imago. Río Cidra, Adjuntas, P. R. March 24, 1935 (J. G. Needham, J. García-Díaz). No. 1438.2 in Cornell collection.

Paratypes—18 male imagos, 34 female imagos. Luquillo Mts., P. R., June 8–14, 1935 (J. García Díaz); Río Cidra, Adjuntas, P. R. Mch. 24, 1935 (J. G. Needham, J. García-Díaz). No 1438.3–54 in Cornell collection. Of these, one female was reared from the nymph.

Other imagos of this species were taken by Dean García-Díaz at the stations listed above; likewise at La Joba Creek, Río Blanco, P. R., Mch. 7, 1935. A speimen from the Luquillo Mts. is dated Feb. 18, 1935. Nymphs were collected at Lares, Guajataca Creek, P. R., on Mch. 22 at Río Prieto, Río Blanco, Mch. 7, 1935.

Neohagenulus luteolus, sp. nov.

Larger and paler than *N. julio* or *N. tinctus*. Wing veins amber or yellowish. Fore tibia of male whitish except tip, femur red-brown.

Male imago—Body 6½–7 mm.; wings 7 m..

Head yellowish. Black markings on frontal area, at bases of antennae, and around ocelli. Upper portion of compound eyes orange. Ocelli milky white. Antennae pale. Pronotum yellowish with reddish tinge; margins, and a curved, lateral, streak on each side, black. Mesonotum concolorous with pronotum; scutellum smoky. Pleura light reddish brown; a wide, blackish, streak anterior to wing roots, enclosing a pale line; black shading below wing roots and around bases of legs. Anterior half of metanotum red-brown, margined posteriorly with black. Posterior half yellowish; black, lateral, spot above leg base.

Sternum darker red-brown. Sutures, and lateral areas of mesosternum behind middle legs, yellowish.

Fore femur rather dark red-brown, with narrow, black, pre-apical, line; extreme tip yellowish. Tibia very pale, yellowish or whitish; a rather wide, pre-apical, purplish black, band, and a dark streak backward from this along lower margin, to about middle of segment. Tarsus pale yellowish; distal joint faintly smoky; a pale smoky streak along lower margin. Middle and hind legs pale yellowish. Two small, black, spots, unequal in size, near apex of each femur, and a faint blackish, longitudinal, hair-line above center of each. A smoky longitudinal streak near middle of hind femur, on some specimens (not present in holotype). Wings hyaline. All veins pale amber to yellowish; those in cubito-anal area often so pale as to be invisible. Cross veins distinct in first three spaces behind costal margin only. 8 to 9 stigmatic cross veins, slightly aslant, are somewhat heavier than others; entire stigmatic area very faintly amber-tinged. Extreme base of costa, to humeral cross vein, thickened and blackish; costal space before this cross vein reddish brown. Costal margin and first vein in hind wing purplish grey at base. Hind wing as in figure 47.

Abdomen pale yellowish or whitish (no reddish tinges except at base and apex), with greyish black, dorsal, markings. Posterior margins of all tergites rather widely dark; lateral area of each likewise deep grey, this dark band enclosing a pale V-shaped mark which does not reach to posterior margin. Median area of each tergite hyaline, wholly whitish except for dark posterior band; outer margin of this pale area curved, ( ). A small black spot over spiracle. Segments 8–10 opaque, tinged strongly with reddish brown. Sternites 1 and 2 likewise reddish brown with smoky tinge; 2 paler than 1; each with two hyaline submedian marks, which are dots on 1, streaks bounding the darkened ganglionic area on 2. Sternites 3–7 pale, hyaline; posterior margins, and a lateral streak paralleling the pleural fold, smoky brown. Tails (missing from holotype) pale yellowish white; joinings black, alternately wide and narrow, the narrow joinings less darkened.

One of the male paratypes differs from the above description thus: head and entire thorax reddish brown, sternites 2–7 with distinct purplish-red tinge.

Female imago.—Head purplish black; two small, pale, submedian, spots on occiput; a pale, narrow, transverse, line between lateral ocelli; pale areas along posterior margin, at bases of antennae, and on outer margin of each lateral ocellus. Antenna yellowish; second joint blackish in apical third. Thorax light reddish brown. Lateral margins, and almost the entire median area of pronotum, blackish. Mesonotal scutellum, and median streak directly anterior to it, blackish. Pleura as in male. Sternum paler than dorsum. Median area, and anterior margin of mesosternum, darker (however, posterior half of mesosternum is pale).

Fore femur dark reddish brown; tibia blackish; tarsus pale, a smoky blotch near apices of 2nd, 3rd and 4th segments, on lower margins; a reddish-black line at apex of distal segment. Middle and hind femora yellowish, with reddish tinge, most evident on hind femur and at apex of each; a longitudinal, black, hair-line extends the length of each; near apex of each, a black spot. Middle tibia deep smoky, hind tibia somewhat paler. Tarsi similar to fore leg, but smoky markings paler. Wings hyaline, brown-tinged throughout. All veins reddish brown. Costal band on fore wing reddish brown, as in *N. tinctus.*

Cross veins somewhat less distinct than in that species, especially behind the outer fork. Wing broader in proportion to its length than in *tinctus.*

Dorsum of abdomen predominantly blackish brown; pale areas yellowish, with faint reddish tinge. Dark dorsal areas much as in male, but more extensive, on tergites 1–7. The pale, lateral, mark surrounded by dark shading is wider than in the male, and curves dorsad apically. The pale, median, areas are smaller than in the male, becoming progressively larger in size from base toward apical tergites. On tergite 8, only small, lateral, areas and a narrow, posterior, margin are darkened, so that the tergite is largely pale. Tergites 9 and 10 are almost wholly yellowish; anterior margin of 9, posterior margin of 10, and lateral margins of each, blackish. Traces of dark, submedian, streaks are visible within the pale median patches, on tergites 1–7. Sternite 1 somewhat tinged with reddish brown; all other sternites yellow; posterior margins very narrowly darkened. Faint dark median markings on sternite 6, and around egg valve on sternite 7. Tails greyish brown; alternate joinings blackish.

In both paratypes, the pale, median, areas on the tergites are much reduced in size, as compared with the above description. (The middle and apical portion of abdomen is missing, in one paratype).

Nymph.—Distinguished from *N. julio* and *N. tinctus* by: 1) the somewhat larger size; 2) the shorter spines on femora and tibiae (figs. 15, 17); 3) the fact that that there is no continuous pale area between eye and ocellus; 4) the *median* dark ventral mark.

Head dark reddish brown, heavily shaded with black between and immediately anterior to eyes. Yellowish areas around antennae, at outer margin of each lateral ocellus, and at inner margin of each eye. Thus, there is no continuous pale space between eye and ocellus. Antennae wholly pale. Median portion of occipital border, and four submedian spots on occiput (the anterior pair of these the larger), are pale reddish. Labrum 2½ times as wide as long; in *tinctus, julio,* 2 times as wide. Thorax as in *julio.* Legs yellowish, distinctly tinged with pale reddish brown. Basal third of fore femur wholly pale. Two black spots, unequal in size, at apex of each femur. Spines on femora and tibiae shorter, much less prominent than in *julio* or *tinctus.* Abdomen of female nymph largely blackish brown dorsally, on tergites 1–8; pale median and lateral marks as in adult; median area of 8 more extensive than on preceding tergites. Tergites 9 and 10 almost wholly pale; lateral margins darkened, also posterior margin of 10. Dorsum of male with larger pale areas, as in adult. Venter of abdomen yellowish. A short, black, median, transverse, mark on each sternite, somewhat anterior to the posterior margin. Tails wholly yellowish, except in mature nymph. Gills with a greater number of short, lateral, branches than in *julio, tinctus.*

Holotype—Male imago, reared from nymph. Camp lab. 46, Luquillo Mts., P. R., June 9, 1935 (J. García-Díaz). No. 1439.1 in Cornell University collection.

Allotype—Female imago, reared. Same data No. 1439.2 in Cornell collection.

Paratypes—2 male imagos, 2 female imagos. Same locality same collector. June 7–14, 1935. No. 1439.3–6 in Cornell collection.

In addition to the three reared species of Neohagenulus, many specimens of nymphs of a distinctly larger size are present in the Puerto Rican material. None of these has been reared. Two different species seem to be represented; these are designated by number only.

Neohagenulus sp. No. 1

Nymph.—Body of female 7–8 mm. in length. Second joint of antenna black. Spines on femora and tibiae relatively long, as in *N. julio* and *N. tinctus*. Pale area between eye and ocellus not divided by a dark line. Head and thorax red-brown. Abdomen of mature female dark red-brown dorsally. On each tergite, dark, submedian, streaks enclose a pale, median, line; a pair of pale, submedian, spots at anterior margin; lateral markings as in *tinctus*. Venter paler red-brown; anterior margins of each sternite narrowly darkened; intersegmental areas pale; an oblique, dark, mark on each side near posterior margin, halfway between median line and lateral margin. A single large female imago, body marked as in nymph, may represent the mature form of this species.

Nymphs of this species were collected at El Rucio, P. R., in 1934 (Dr. Francisco M. Pagán). Other specimens are from Guajataca Creek, Lares, P. R., Mch. 22, 1935 (J. G. Needham, J. García-Díaz); Río Prieto, Río Blanco, P. R., Mch. 7, '35 (Needham, García-Díaz); El Yunque Trail, Luquillo Mts., June 10, '35 (J. García-Díaz). The large female imago was taken at La Catalina, Luquillo Mts., Apl. 15, 1935 (J. García-Díaz).

Neohagenulus sp. No. 2

Nymph.—Body of female 7–8 mm. in length.

Head pale red-brown. Pale area between eye and ocellus not divided by a dark line. Antenna wholly pale. Thorax yellowish to pale reddish brown; dark markings as in the species previously described. Spines on femora and tibiae about intermediate in length between those of *N. luteolus* and the other three species. Dorsum of abdomen in both sexes largely yellowish. Posterior and lateral margins of tergites, and a mark near postero-lateral angle of each, blackish. Venter yellowish. Posterior margins of sternites may be narrowly darkened throughout, or the dark area may be confined to the lateral portion of each.

Nymphs of this species are from Río Cidra, Adjuntas, P. R., Mch. 24, 1935 (J. G. Needham, J. García-Díaz); La Catalina, Luquillo Mts., Apl. 14–15, 1929 (J. García-Díaz); and El Yunque Trail, Luquillo Mts., Feb. 18, '35 (Needham, García Díaz). Other specimens taken by Dr. Francisco M. Pagán at El Rucio, Peñuelas, P. R., in 1934, may be of this species, but are too discolored to permit of certain determination.

Genus **Borinquena** gen. nov.

Allied to Hagenulus and Neohagenulus. Rather small mayflies, wings of the known species 5 to 5¾ mm. in length. Upper portion of compound eyes of male much flattened (fig. 22, lateral aspect). In dorsal view, upper portion

is oval; a small area of lower division is also visible from this aspect. Eyes not contiguous apically, separated by distance equal to width of upper portion. Lateral ocelli very large, median ocellus barely visible. Posterior margin of head of female almost straight between the eyes. Pronotum somewhat excavated in middle of posterior margin. Fore legs of male longer than body; tibia fully twice as long as femur, tarsus subequal to tibia; basal tarsal joint very short, 2nd and 3rd joints subequal, 4th about ⅔ as long as the 3rd, 5th about ⅓ as long as 4th. In hind leg of male, femur slightly more than half as long as tibia; tarsus short, about ⅓ the length of the femur. Hind femur of female three-fourths as long as tibia; tarsus as in male. Claws on all tarsi dissimilar.

Fore wing as in figure 4. Outer fork of radial sector deeply sagged at end of stem, in both sexes. Before the bulla, 3 or 4 weak costal cross veins; beyond bulla, 3 to 5 weak veins before stigmatic area, which contains 7 or 8 well developed, slanting, cross veins. Cubital intercalary and first anal vein joined near base. Hind wing very small, drawn out into a long, slender, point; two longitudinal veins only, no cross veins (fig. 10).

Forceps base entire, bearing at median area of apical margin two short, finger-like, processes (fig. 8). Forceps very distinctive; basal joint very long, somewhat narrowed at apex; the two distal joints subequal, together about equal to ¼ of length of basal joint (fig. 12). Penes elongate, rod-like, usually closely appressed on inner margin; each bears on ventral surface a small, hook-like, projection, well below the apex. A correspondingly long ovipositor is borne by the female, as a development of the 7th sternite (fig. 2). Apical margin of subanal plate of female with a deep V-shaped cleft.

Nymph reminiscent of Choroterpes in proportions of head and body and in general appearance, aside from structure of gills. Mouthparts likewise very similar to those of Choroterpes (see figs. 32, 33, 35, 38, 40). Spines on fore femur longer and fewer in number than in *Choroterpes basalis* Bks; on hind femur, reduced to a relatively few short spines on hind margin (in *C. basalis*, these are more numerous and more widely distributed). Hind tibia likewise with relatively few spines, most of these clustered near apex (in *C. basalis*, these spines are very numerous and generally distributed). Claws pectinate. Short postero-lateral spines present on segments 6–9, that on 9 being longest. Gills single, filamentous; each contains a single, unbranched, trachea (figs. 19, 39). Tails three; median tail distinctly longer than laterals, and slightly longer than body of nymph.

Genotype—**Borinquena carmencita**, sp. nov.

The above characterization of the genus is based on the genotype, and does not hold for the abnormal species *B. contradicens* as regards shape of hind wings and length of male forceps.

Key to Species of Borinquena

ADULTS

1. **Wing very much reduced, having but two longitudinal veins, no cross veins; forceps of male very long, equal to combined lengths of last three ab-**

dominal segments; abdominal tergites of male yellowish, wings brown-tinged ---------- *carmencita*

Wing much less reduced, having four longitudinal and several cross veins; forceps of male shorter; abdominal tergites of male whitish, wings not tinged ---------- *contradicens*

NYMPHS

1. Gills distinctly widened in basal third of their length; abdominal tergites of male yellowish, dark posterior margins narrow ---------- *contradicens*

   Gills tapering more uniformly, not distinctly widened at base; abdominal tergites 7 and 10 of male wholly yellow, 8 and 9 blackish; dark posterior margins of other tergites wide ---------- *carmencita*

Borinquena carmencita sp. nov.

Wings faintly brown-tinged; abdomen yellowish, dark-banded dorsally.

Male imago.—Body 5½ mm.; wing 5–5½ mm.

Head very dark red-brown; antennae brown; lateral ocelli pearly white; eyes blue-black. Pronotum yellowish brown; lateral margin and postero-lateral angle dusky. Anterior margin of prothoracic pleura blackish; an oblique streak across central portion. Mesonotum rather dark red-brown; anterior lobe deep orange; posterior half of median line, including middle of scutellum, and oblique, lateral, extensions forward from median line to wing roots, yellowish. Pleura pale red-brown, yellowish around leg bases. Wide, purplish black, stripe extends forward from wing roots; blackish markings below wings and near leg bases. Metanotum olive brown; posterior margin and scutellum dusky. Sternum red-brown, darkest across anterior portion of mesosternum. Coxa and trochanter red-brown. Fore femur deep purplish brown, with prominent yellow, pre-apical, band; pale brown at base. Middle and hind femora similar, but distinctly yellowish at base. Tibiae dark olive brown, with faint red-brown tinge. Fore tarsus similar to tibia but paler. On middle and hind legs, basal and distal joints of tarsi yellowish, intermediate joints light red-brown, joinings very narrowly yellow. Wings hyaline, iridescent, faintly brown-tinged (figs. 4, 10). Venation dark red-brown.

Abdomen yellowish, semi-opaque. Tergites 1–6 with wide, purplish black, posterior, margins, these bands widest at middle and at each end; at median line, a pale streak may divide the anterior half of this dark border. Anterior extensions from each end of this dark band form an elongate, dark, oval, mark enclosing a pale area; its sides are two dark lines parallel to the pleural fold, conjoined at each end, and extending forward almost to the anterior margin. The dark oval is not well defined, on tergite 6. On tergite 7, the dark posterior band is narrower, and has no lateral extensions; a round, dark, spot is present near the postero-lateral angle, another at spiracular area; on some specimens, a smaller, dark, dot may occur between these. Dusky shading also occurs along the anterior margin of each intermediate tergite, usually as small patches on each side of median line. Geminate, dark, mid-dorsal, streaks are faintly indicated on some specimens, most distinct at each margin. Tergites 8 and 9 largely deep purplish brown; anterior margin of 8, area adjoining posterior margin of 9, traces of median streak, and wide, lateral, margins are yellowish.

Tergite 10 yellow, with reddish tinge. Sternites 1–7 with posterior margins faintly dusky; sternites 8 and 9 tinged with light red-brown. Tails dark olive brown with reddish tinge; joinings darker. Genitalia as in figures 12 and 37. Forceps base light red-brown; forceps dusky, darker at apex of long joint.

Specimens taken on June 7, in the same locality as the holotype, appear much darker; pale bands on femora more or less obscured; posterior dark borders on abdominal tergites more extensive; thorax deeper red-bown; wings more strongly brown-tinged; all markings more intense in color. No structural differences are noticeable. Nymphs of these darker forms are not known, hence it its not possible to determine whether these represent another closely-allied species, or are merely darker forms of the same species.

Female imago.—Body 5½ mm.; wing 5¾ mm.

Very similar to male, aside from usual sex differences. Mesonotum paler brown than in male; a V-shaped yellow mark and an antero-lateral extension of this on each side, anterior to scutellum. Wings as in dark form of male. Abdominal tergites 1–5 largely obscured by blackish shading, leaving on each side a pale, rounded, spot; antero-lateral angles, a narrow, median, line in anterior half, and submedian streaks on each side of dark geminate lines, likewise pale. A wider, pale, band across central area of tergite 6, in dorsal portion. Tergite 7 almost wholly yellowish except for lateral, dark, oval, mark and narrow anterior and posterior margins. Tergites 8 and 9 largely blackish; pale, median, line on each; traces of pale, submedian, streaks at posterior margin of 9; lateral areas of each pale. Tergite 10 yellow. Sternites 7–9 shaded with pale red-brown. Long ovipositor on sternite 7 (fig. 2) extends beyond apex of abdomen for ⅓ of its length; pale yellowish, with dark, longitudinal, streak on each side. Tails somewhat darker than in male.

Nymph.—Frontal portion of head yellow with faint brownish markings. Wide, blackish, band across head between lateral ocelli, usually extending laterad to eyes. Remainder of vertex, and occiput, yellow, more or less obscured by lateral and transverse darker markings, leaving pale posterior margin and a pair of pale, submedian, spots. Thoracic notum yellow; in female, extensive dark markings on median and lateral areas of pronotum, antero-lateral and lateral areas of mesonotum, also dark streaks on each side of central portion of latter segment. In male, these dark areas considerably reduced in size and extent on both segments. Legs yellow; dark markings at middle and apex of femur, in mature nymph. Abdomen yellow, except tergites 8 and 9, which are largely blackish, in both sexes. Posterior margins of tergites 1–6 with wide, blackish, bands. Sternites unmarked. Gills deep purplish grey, tracheae black; more or less uniform in width throughout, *not* distinctly widened at base (fig. 19). Tails yellow, somewhat opaque at joinings. Postero-lateral spines present on segments 6–9; very small on 6, largest on 9.

Holotype—Male imago. El Yunque, P. R., Feb. 18, 1935 (J. G. Needham, J. García-Díaz). No. 1399.1 in Cornell University collection.

Allotype—Female imago. Luquillo Mts., P. R., June 7, 1935. No. 1399.2 in Cornell collection. Same collectors.

Paratypes—56 male imago, 2 female imagos; El Yunque River, P. R., Feb. 18 and June 7, 1935, and Luquillo Mts., P. R., Feb. 17, 1935. Some collectors. No. 1399.3–57 in Cornell collection.

A single male submago was reared, thus establishing the correct association between nymph and imago. Specimens of this species were taken also from the following localities, during 1935 (J. García-Díaz): Hicaco River, Río Blanco (Mch. 7); and Río Cidra, Adjuntas (Mch. 24).

Borinquena contradicens, sp. nov.

Resembles the type species of this genus in the rearward sag of the outer fork of radial sector and in the genitalia of the male, but with hind wings similar to those of *Hagenulus caligatus* (fig. 50). Female with long ovipositor (fig. 34). Nymph quite like that of *B. carmencita*. Abdomen and legs of male imago whitish; thorax and fore femur red-brown.

Male imago.—Body 5 mm.; wing 5½ mm.

Head blackish brown. Compound eyes deep purplish black in upper portion. Purplish shading on basal joints of antennae; filament silvery white. Thorax largely red-brown. Pronotum, wide strip from wing roots to pronotal margin, and pleura of pro- and mesonota, quite heavily shaded with black. Scutellum, area anterior to and laterad of it, and posterior half of median area of mesonotum, yellowish. Metathorax yellowish; purplish black markings on pleura and around wing roots and leg bases. Posterior half of mesosternum likewise yellowish.

Fore femur red-brown. Tibia and tarsus of fore leg, and entire middle and hind legs, pale yellowish white. A purplish black patch at apex of fore tibia. Apices of middle and hind femora pale reddish yellow. Purplish grey, median, patch on hind femur only. Wings hyaline; both wings red-brown at extreme base (in hind wing, largely in costal strip). Longitudinal veins very pale yellow in upper half of fore wing; in remainder of fore wing and all of hind wing, silvery white. Cross veins fine, silvery white; almost invisible except in stigmatic area. Nine to eleven cross veins in this area; slightly aslant, yellow-tinged, and more distinct than cross veins elsewhere. Outer fork of radial sector in fore wing sagged prominently to rearward. Hind wing shown in fig. 50, 50 B.

Abdomen whitish; middle segments hyaline, basal and apical ones opaque. Posterior margins of tergites 3–10 narrowly purplish black, widest at median line; on 3 and 4, dark in median area only. Oblique, lateral, streaks of the same dark color extend the length of the segment on tergites 7–10; on 5 and 6 these streaks may be incomplete at apical margin; not present on basal segments. On tergites 2–8, a purplish black, stigmatic, dot; short, black, marks from the ends of the posterior dark bands extend obliquely above these dots on tergites 4–8. A small, dark, spot on median line above the apical margin, on tergite 5; a larger, dark, blotch on antero-median area of tergite 9. Sternites unmarked. Genitalia as in figs. 36, 41. Tails silvery white; a purplish-black ring at each joining.

Female (subimago ready to transform, cuticle partially removed). Body 3½–4 mm.; wing 5 mm.

Body largely red-brown. Head and eyes blackish. Pronotum and mesothoracic pleura heavily shaded with black. Mesonotal shield and median portion of mesosternum paler, yellowish to olive brown. Tip of scutellum brown. Metanotum yellowish; black markings laterally, especially around bases of legs. Legs (cuticle not removed) red-brown; fore leg darker than hind leg. Purplish, median, blotch on hind femur; apex dark red-brown. Wings (cuticle removed from fore wing) hyaline. Costal space basad of humeral cross vein dark red-brown. Humeral cross vein, costal margin, and subcosta, red-brown; radius and first branch of radial sector same color, but less prominent. Cross veins from costal margin to first branch of radial sector light red-brown, fairly distinct, especially those in the stigmatic area, which are about 9 in number, and slightly aslant. Hind wing red-brown in basal costal space; tip, and entire outer margin, darkened.

Abdomen red-brown dorsally, mottled with black. Median areas of tergites 5–7 yellowish; pale, submedian, streaks on tergites 3 and 4. Posterior margins of all tergites purplish black, the dark band occupying about ¼ of each tergite. Sternites 1–6 pale yellowish, 7–9 tinged with reddish brown. Posterior margins darkened, very faintly across median area, distinctly next to pleural fold. Tails (cuticle not removed) greyish, all joinings black. Long ovipositor present, as in *B. carmencita* (fig. 34).

Nymph.—Body 5 mm. in length. Head yellowish. Irregular, pale brown, markings on frontal portion. A blackish, curved, mark on each side of base of antenna. Antenna yellowish; second joint may be darkened near base. A broad, blackish-brown, band extends across head between eyes, including the lateral ocelli. Posterior to this band, much grey shading; pale areas include a narrow strip behind the dark band, and three pairs of elongate-oval, submedian, spots, those nearest the posterior margin being longest. Pronotum greyish brown, with large, bilobed, yellowish, areas on each side. Mesonotum yellowish. Dark markings along postero-lateral margins; short, dark, submedian, streaks may be present. Blackish shading in antero-lateral areas, extending backward to wing roots. Metanotum yellowish; irregular brown, lateral, markings. Sternum yellowish white. Legs yellowish, in immature nymphs. Traces of dark median and apical bands, on hind femur only, in young nymphs; mature specimens may have dark shading and femoral bands on other legs also. Abdominal tergites 1–3 of female nymph blackish brown; tergites 4–8 same dark color laterally, but each with a large, pale, median area, these pale spots becoming progressively larger in size from tergite 4 toward apex. Tergites 9 and 10 largely yellow; 9 with narrow dark anterior margin. Abdominal tergites of male nymph yellowish, with narrow, dark, posterior, and oblique, lateral, dark markings, as in adult. Sternites of both sexes yellowish, unmarked. Tails of immature nymphs wholly yellowish, or silvery white; mature nymphs similar to adults. Gills distinctly widened in basal third (fig. 39); dark grey, tracheae black. Postero-lateral spines on 8 and 9 (no true processes on other segments) shorter than in *B. carmencita.*

Holotype—Male imago. La Mina Recreational Area, P. R., July 14, 1935 (J. García-Díaz). No. 1440.1 in Cornell University collection.

Allotype—Female subimago, reared from nymph. Luquillo Mts., P. R., June 8, 1935 (J. García-Díaz). No. 1440.2 in Cornell collection.

Paratypes—2 male subimagos, 1 female subimago, reared from nymphs. Luquillo Mts., P. R., June 8–14, 1935 (J. García-Díaz). No. 1440.3–5 in Cornell collection.

Nymphs of this species were taken in the Luquillo Mts. P. R., on Feb. 18, 1935 (J. G. Needham, J. García-Díaz).

SUBFAMILY CAENINAE

Genus *Caenis* Stephens

Three species of this genus are represented, one by a female imago reared from the nymph, one by a female imago and tentatively associated nymph, the other by a single nymph. These may be distinguished as follows.

Key to Puerto Rican Species of Caenis

ADULT FEMALES

1. Five longitudinal black stripes on mesonotum; no dark markings on femur ---------- *sp. No. 1*
   A single dark, median, line on mesonotum; two incomplete, blackish, bands and a longitudinal, black, hair-line on femur ---------- *sp. No. 2*

NYMPHS

1. Dark area at base of antenna; abdominal tergites largely suffused with blackish ---------- *sp. No. 2*
   No such dark area at base of antenna; abdominal markings somewhat more restricted ---------- 2
2. Posterior portion of head largely yellowish; numerous small yellow spots on mesonotum; dark markings on apical tergites largely restricted to lateral areas ---------- *sp. No. 3*
   Posterior portion of head largely brown; mesonotal markings diffuse streaks; dark markings on abdominal tergites largely transverse bands ---------- *sp. No. 1*

Caenis sp. No. 1

Female imago.—Body 3 mm.; wing 2½ mm.

Head heavily shaded with purplish black. Antennae pale. Pronotum greyish, margined and heavily shaded with black. Mesonotum reddish brown, with five longitudinal, black, stripes, one of these on median line. Pleura and sternum yellowish to light reddish brown, darker at sutures. Venation purplish grey. Legs light reddish brown; two black streaks on each coxa, no other markings. Abdomen yellow. Wide, black, bands on posterior margin of each tergite, the blackish shading often extending over half the segment. Tails missing.

Taken at Río Piedras River, P. R., May 23, 1935 (J. García-Díaz).

Two specimens, reared from nymphs. Head and thorax of nymph reddish brown with yellow markings. Black band on head between bases of antennae, another between eyes. Antennae yellowish. Two yellow spots on head, one between bases of antennae, the other along median line of vertex and occiput. Median, dark, band on femur; wide dark band basally on tibia, similar band on tarsus. Anterior margin of pronotum rather widely flaring. Abdomen yellowish with black markings as in adult.

Caenis sp. No. 2

Female (imago removed from subimaginal skin).

Body 4 mm.; wing 3½ mm.

Head yellowish; black shading between eyes. Antennae blackish at base. Pronotum light reddish brown, with much black shading. Mesonotum reddish brown; median line, and streak anterior to wing roots, blackish. Pleura and sternum light red-brown; dark markings on pleura at bases of legs. Black shading on coxa; a black dot on trochanter; two incomplete, blackish, bands on femur, one near base, the other near apex, likewise a longitudinal, black, hair-line along margin. Venation light purplish grey. Abdomen yellowish. Tergites more or less completely suffused with irregular blackish mottling, which on basal ones tends to form dark, posterior, bands. Tails yellowish at base, paler apically; not darkened at joinings.

Río Piedras River, P. R., May 23, 1935 (J. García-Díaz).

A single specimen. A last-stage nymph, about to transform, taken at same time and place, is tentatively associated with this female, because of dark area at base of antennae, the diffuse dark abdominal markings, and the single dark, median, line on the exposed mesonotum of the subimago. Anterior margin of pronotum less flaring than in nymph of *Caenis sp. No. 1;* dark markings on abdominal tergites rather more suffused. Legs missing.

Caenis sp. No. 3

This species is represented by a single nymph, taken at same time and place as other two species. Body more slender than in either of the two preceding species. Head largely yellowish, except for wide, dark, bands between bases of antennae and eyes, narrow continuations from these bands forward to the clypeus, and brownish, lateral, streaks extending forward from the narrowly dark posterior margin. Antennae yellowish. Pronotum mainly blackish, but with a large, yellowish, spot on each side and another on posterior half of median line. A series of small, yellow, spots on the red-brown mesonotum are located as follows: one large spot on each side anterior to wing roots; one large spot laterally on anterior line; four small spots between median line and wing roots; and a pale, oblique, streak on anterior margin at median line. Two small, black, submedian, spots near posterior margin of mesonotum, behind these a pale area. Costal margin of wing pad heavily shaded with blackish. Legs yellowish. Pre-apical black spot and diffuse band on each femur; dark proximal

band on each tibia, another near base of tarsus on fore leg only. Dark marks on pleura above bases of middle and hind legs; small, dark, streak at apex of trochanter on these legs. Abdominal segments yellow; basal tergites heavily suffused with blackish; tergite 10 yellow-brown with no black markings; other tergites pale in median area and along each margin, lateral areas blackish. Tails yellow, not darker at joinings.

SUBFAMILY BAETINAE

The three genera Baetis, Callibaetis, and Cloeodes are represented in this material. These may be distinguished as indicated in the following keys.

KEY TO PUERTO RICAN GENERA OF BAETINAE

ADULTS

1. Hind wing present ---------- 2
   Hind wing absent ---------- *Cloeodes*
2. Fore wings usually with numerous costal cross veins before the bulla; hind wings with a moderate number of cross veins, the costal projection obtuse ---------- *Callibaetis*
   Fore wings without costal cross veins before the bulla; hind wings with no cross veins, or very few of them; costal projection acute, may be hook-like ---------- *Baetis*

KEY TO PUERTO RICAN GENERA OF BAETINAE

NYMPHS

1. Gills single on segments 1–7 ---------- 2
   Gills double on segments 1–6, single on 7 ---------- *Callibaetis*
2. Hind wing bud present ---------- *Baetis*
   Hind wing bud absent ---------- *Cloeodes*

Genus *Callibaetis* Eaton

Females and nymphs of this genus were collected. The nymphs were not reared, hence cannot be associated with the female except by inference.

Callibaetis completa (?) Bks. (2)

Several females taken in September 1930 (Francisco Seín), at the Experiment Station, Río Piedras, P. R., are tentatively placed in this species. The specimens are in rather poor condition, so that it is difficult to be certain of the markings on the body. No dark dots are evident on the thorax. Scutellum of mesonotum, and spine-like median process of metanotum, dark brown. In some specimens, the median area of the mesonotum likewise appears darker than other parts. The second joint of the antenna is slightly brown-shaded, in some specimens. Of this, Banks states: "second joint of antenna mostly dark brown." Legs yellowish, having no dark dots; femoro-tibial joint red-brown; tarsal joinings narrowly dark; claws dark brown.

Wings much as described by Banks: "a broad brown stripe along front margin, covering the first three veins, and on base a little more; this brown fills the costal area to base, and also at tip, it contains a number of transverse hyaline white marks, mostly over veins, very few of these pale spots in the apical fourth". In the basal half of the costal space, however, are many narrow, pale, areas along the cross veins, usually extending from costal margin to subcosta, but sometimes broken up into two pale spots narrowly separated by a brown line. These pale areas usually extend for a short distance beyond the bulla only, but in a few specimens they occur also at the tip. Pale areas around veins in the subcostal space become round spots, except in the apical fourth, where they are narrow as in the costal strip. In the space below radius appear other and larger, pale, areas around cross veins, connected behind with the hyaline portion of the wing. These large pale spots are 5 to 7 in number; the largest occur near the bulla. All veins brownish. Cross veins behind the brown band about 22 in number; none very near the margin. Marginal intercalaries occur singly.

Few or no small, dark, dots on abdomen, but larger, paired, submedian, dark, spots or marks on tergites and sternites; those of the tergites seem confined to the basal and middle segments, and the area between them appears to be darkened. Of *C. completa*, Banks says: "body of usual pale brownish, with many small, dark, dots, especially on the abdomen, beneath with larger, paired, dots, above on the abdomen the basal segments show a large, dark, spot in the middle, tending to form a stripe." Tails whitish; dark-ringed at joinings, the rings of alternate joints wider and darker.

Rather variable in size; wings ranging in length from 5 to 7½ mm. The length of *C. completa* is given as 7½ mm.; type locality, Soledad, Cuba.

Callibaetis sp.

Nymph.—Head and thorax dark red-brown. Pale areas around eyes, antennae and ocelli; vertex and occiput indistinctly mottled, median line pale. Mouthparts normal for the genus. Median line of thoracic notum pale, likewise tip of scutellum and areas anterior to wing roots. Pleura and sternum paler red-brown; darker areas on pleura above leg bases. Legs light red-brown; joinings very narrowly darker. No distinct markings. Abdominal tergites red-brown; intersegmental areas pale, so that abdomen often appears banded. A narrow, yellow, lateral, line half-way to margin extends the length of the abdomen, but is usually concealed beneath the large gills. Pale areas on flattened lateral portion along anterior margin, so that this portion of the abdomen is alternately dark and light. A darker spot at base of each pair of gills. Sternite paler; a wide, median, band, obscurely darker red-brown, extends the length of the abdomen; on each side a row of small, dark, dots, located near anterior margin of sternite. Gills double on segments 1–6, single on 7; large, with lower division of each pair (at least on intermediate segments) almost as large as the upper, and very similar in shape. Tracheation approaching the palmate condition; tracheae purplish black, prominent, numerous. Tails yellowish to pale reddish brown, joinings narrowly darker. A wide, dark, band across tail, formed by an area of long dark hairs.

Body 6–7 mm.; tails 4½ mm.

Specimens were collected during 1935 at Tortuguero Lake, west end, Mch. 9 (J. García-Díaz); Cartagena Lagoon, Feb. 23 and Aug. 10 (J. García-Díaz); Florida Road, Feb. 28 (J. G.-D.); Experiment Station, Río Piedras, May 23 (J. G.-D.). On May 5, 1931, Dean García-Díaz took other similar nymphs at Las Cabezas, Fajardo.

While it is probable that *Callibaetis sp.* is the nymph of *C. completa* (?) Bks., this can be determined only by rearing of the nymphs. In this way, too, it should be possible to obtain the male, and other specimens of females which are in better condition for determination.

Genus *Baetis* Leach

Three species of Baetis are present, one of which has been reared; the other two are represented by nymphs only. Nymphs may be separated as indicated below.

Key to Puerto Rican Species of Baetis

NYMPHS

1. Intermediate gills asymmetrical; each about as long as one abdominal segment plus half of another ---------- 2
   Intermediate gills symmetrical; each about as long as three abdominal segments together ---------- *sp. No. 1*
2. Gills on segment 7 distinctly narrower and smaller than those on 6; two dark bands on tail ---------- *garcianus*
   Gill on 7 very similar to that on 8; a single dark apical band on tail ---------- *sp. No. 2*

Baetis garcianus sp. nov.

Male imago.—Body 3½ to 4 mm.; wing 4 to 4½ mm.

Head rather dark reddish brown; antennae and eyes the same color. Turbinate eyes oval, set on high stalks. Thorax dark reddish brown; intersegmental areas of pleura, narrow stripes on each side of mesonotum, and areas around bases of legs and wings, paler. Legs pale yellowish white; coxae largely brown; narrow, dark brown, line at apex of trochanter and at each tarsal joinings. Wings hyaline. Longitudinal veins very faintly brownish in apical and basal portions; wing margin outlined in brown. Costa and subcosta deeper brown at extreme base; a small, dark, spot at base of subcosta and radius. Cross veins colorless. Stigmatic space and parallel subcostal space semi-opaque, filled with granulations. Three or four slanting, stigmatic cross veins, incomplete toward subcosta. No marginal intercalaries in first interspace, or in anal area; between media and cubitus, these may occur singly, elsewhere paired as usual. Hind wing very slender, with strongly hooked, costal angulation, reminiscent of Centroptilum (fig. 9). Two veins only, the first of these usually incomplete at apex; a faint brownish yellow stain at extreme base.

Abdominal segments 2–6 hyaline whitish. Posterior margins of tergites narrowly deep brown, in dorsal portion only; these marks often much fainter at median line. Postero-lateral area of each tergite occupied by a large olive-brown blotch, almost square, but with its anterior margin slightly concave. Antero-lateral areas remain hyaline white. On tergite 2, the upper anterior angle of the dark blotch extends forward almost to the basal margin of the tergite. Dorsum of abdomen thus appears pale in middle area, with a wide, broken, brown, band on each side. Tergites 7–10 deep red-brown, pleural margin paler; sternites olive brown with a faint reddish tinge. Tails white, tinged with yellowish at base; joinings opaque but not darkened. Genitalia as shown in figure 5.

Female imago.—Body 3½–4½ mm.; wing 4¼–4½ mm.

Head yellowish; narrow pale median line on vertex, lateral areas mottled with dark brown. Pronotum dark red-brown; median stripe and lateral areas pale. Mesothorax light red-brown; darker brown markings anterior to wing root; tip of scutellum whitish. Two pale, longitudinal, streaks on sternum. Metathorax dark red-brown. Legs as in male. All veins distinctly brownish; stigmatic cross veins 5 or 6 in number, better developed than in male. Abdominal tergites largely chestnut brown, with creamy markings. These pale areas include the antero-lateral angles, a narrow line along the anterior margin, basal half of median line, short, submedian, dashes from anterior margin, a small dot at end of each dash, and a lateral triangle based on posterior margin. Tergites 8–10 paler than preceding ones. Pleural fold widely pale; small dark stigmatic dots, and a wavy, double, blackish, line along tracheal area. Sternites pale yellowish; dark red-brown shading next to pleural fold, and a transverse, brown, dash in each antero-lateral angle. Tails very faintly brown-tinged at base.

Nymph (described from nymph slough of allotype, with additional notes from nearly-mature nymphs). Head light reddish brown; whitish areas around eyes, ocelli, and bases of antenae; antennae likewise whitish. Maxillary palp two-jointed; labial palp three-jointed, very similar to that of *Baetis sp. No. 1*, shown in figure 25. Epicranial suture and median line of vertex whitish. Thoracic notum concolorous with head; median line whitish; diffuse darker markings and a few creamy areas anterior to wing roots. Pleura and sternum paler reddish brown; brownish semi-lunar markings above leg bases. Legs pale yellowish, femora often with faint brownish tinge; obscure brownish, pre-apical, mark on femur; a distinct dark brown "knee spot"; all joinings narrowly dark brown. Claws amber-tinged; pectinate. Abdominal tergites 1–7 slightly darker brown than thoracic notum; tergites 8–10 paler, 9 and basal half of 10 usually yellowish. All tergites paler next to dark lateral margin. A diffuse pale, median, line on anterior half of each tergite, with obscure darker areas on each side. All margins narrowly darker; posterior and lateral margins of 10 widely dark; postero-lateral angles of all segments greyish brown, with a darker spot at base of gill. Sternites slightly paler than tergites; faint dark, lateral, streaks and obscure, obliquely-directed, submedian, dashes from anterior margin are often evident. Gills single, obovate, those of intermediate pairs asymmetrical (fig. 23). Tracheation pinnate; tracheae purplish black, conspicuous; main branch not extending as far as tip of gill, lateral branches not very numerous. Tails yellowish brown, crossed by two wide, dark,

bands; middle tail about two-thirds the length of the laterals. Body 4½–5 mm.; tails 3–3½ mm.

Holotype—Male imago. Tanama River, P. R., March 13, 1935 (J. G. Needham, J. García-Díaz). No. 1400.1 in Cornell University collection.

Allotype—Female imago, reared from nymph. Yunez River, P. R., June 21, 1935 (J. García-Díaz). No 1400.2 in Cornell collection.

Paratypes—23 male imagos, same data as holotype; 4 male imagos, Tanama River, May 12 (J. García-Díaz); 17 female imagos, same data as allotype. No. 1400.3–43 in Cornell collection.

A male and female imago which seem to be of this species were collected at Isabela, P. R., April 24, 1930, and a male at Las Cruces, P. ., April 4, 1930, by Dr. M. D. Leonard. These specimens are in the Cornell collection. Nymphs similar to that from which the allotype was reared were taken during 1935 (J. García-Díaz) at Río Cidra (Mch. 23); Luquillo Mts., (Feb. 18, May 26); Quebrada Tomey (Feb. 21); La Muda River (Feb. 9); Carrera River (Mch. 9); Utuado Road (Mch. 13); Yunez River (Feb. 19, June 22 and Aug. 15; Lares, Guajataca Creek (Mch. 22); Tallaboa Alta River (Feb. 25); Cagüitas River (Mch. 4); Almirante Road (Mch. 9); and Mameyes River (Mch. 8).

The species described by Eaton (6), from the Rangel Mts., Cuba, as *Centroptilum poeyi* Etn., is probably a Baetis of the same aberrant type as *B. garcianus*. Abdominal segments 2–6 of *poeyi* are "transparent whitish", unmarked except that "the spiracles and tracheal trunks [are] darker in individual specimens". The narrow, dark, posterior, margins of the tergites, and the lateral, brownish, blotches of *garcianus*, serve as distinguishing features. Were it not that *B. garcianus* was reared from a typical Baetis nymph, it would have been very difficult to decide whether to place this species in Baetis or Centroptilum. Eaton notes: "interneural veinlets of the terminal margin mostly in pairs,"—a condition distinctly reminiscent of Baetis. The hind wing, however, appears to be that of a Centroptilum.

Baetis sp. No. 1

Disconcertingly close to *B. garcianus* in general appearance, but slightly smaller, and differing in the shape and size of the gills.

Nymph—Head very much as in *B. garcianus*. Maxillary and labial palps as in that species; labial palp shown in figure 25. Thoracic notum somewhat more conspicuously marked. Distinct paler areas anterior to wing roots, in-

terspersed with darker markings; on each side of mesonotum an oblique, paler, streak, containing a dark mark, and surrounded by darker areas. Paler mottling laterally on pronotum. Pleura and sternum paler relatively than in *B. garcianus*, the dark, semi-lunar, markings above leg bases therefore more conspicuous. Legs quite similar, but pre-apical band on femur has here become a wider, longitudinal, streak in apical half of the joint, and the dark knee spot is reduced to a narrow line at the femoro-tibial joining. Abdominal tergite 1 and the extreme base of 10 pale; remaining tergites rather uniformly dark red-brown. Marked as in *B. garcianus*, except that the posterior margins are distinctly darker; dark brown shading occurs in a crescentic area based on this margin, or in some specimens as more or less distinct wide, submedian, streaks the length of each tergite; and the pale, median, stripe is practically continuous. Sternites as in the former species, but posterior margins usually obscurely darker. Gills longer, relatively more slender, intermediate pairs more symmetrical, the tips less distinctly rounded (fig. 24). Gill on 7th segment almost as long and as wide as that on the 6th (in *B. garcianus*, this gill is shorter and distinctly narrower than the one preceding), so that its tip may extend beyond the apical margin of the 10th segment. Each intermediate gill is approximately as long as any three of the middle segments of the abdomen taken together. Tails yellowish brown, may be slightly darker at base; in distal half, each joint of lateral tails is darker brown apically, giving the appearance of an obscure darker band near the base, as in *B. garcianus*. Middle slightly more than one half as long as the laterals.

Body 3–4 mm.; tails 3–3½ mm.

Nymphs of this species were taken at the following localities during 1935 (J. G. Needham, J. García-Díaz): Utuado Road (Mch. 13); Luquillo Mts. (May 26); Caño Tiburones (Mch. 12); Cagüitas River (Mch. 4); and Quebrada Tomey (Feb. 21).

Baetis sp. No. 2

Larger than either of the preceding species. One dark apical band on tail.

Body (female) 6–7 mm. Head and thorax pale reddish brown; pale, median, line from frontal suture to posterior margin of metanotum. Pale submedian areas on mesonotum. Darker shading anterior to wing roots. Maxillary palp as in *B. garcianus;* labial palp more like that of *Baetis sp. No. 1.* Legs yellowish. Very faint pre-apical bands on femora; femoro-tibial joint dark brown; claw and tarsal joinings brownish. Tergites 1 and 9 wholly pale yellowish; tergite 4 pale except for brown, anterior, margin and two small, dark, submedian, dots; tergite 10 pale in anterior half, brown posteriorly; tergite 8 largely pale, but with four dark, submedian, marks, one pair on anterior margin, other pair (closer together) near center of tergite. Tergites 2 and 7 dark brown except for pale line near lateral margin; tergites 3, 5, and 6 largely brown, but with pale, transverse, areas, on 5 and 6 a bar near anterior margin, on 3 a more extensive area nearer center. Sternites yellowish white, unmarked.

Gills pale greyish white; tracheae and margins of gills blackish. Tracheae pinnate, intermediate in number of branches between *B. garcianus* and *Baetis sp. No. 1.* Gills slightly asymmetrical, resembling those of *B. garcianus* in shape and relative length. Tails yellowish, with single, dark, apical, band.

Three specimens were taken in the Luquillo Mts., El Yunque Trail, July 27, 1935 (J. García-Díaz).

Discussion of the genus Pseudocloeon Klapalek and allied forms

Three species of Baetine imagos, which by the absence of the hind wing and the paired marginal, intercalaries of the fore wing (these often single, in the females) would fall into the genus Pseudocloeon, are present in the Puerto Rican material. Three specimens representing two species were reared from nymphs. The nymphs possess three tails, almost equal in length and thickness; labial palp apparently two-jointed in one species, ending distally in a pointed projection, in the other species three jointed, distal joint rounded apically; claws without pectinations. The imago of one species corresponds well with characterizations of the type of Pseudocloeon as to relative lengths of leg joints; in the other species, however, the basal joint of the tarsus is very long. Thus these two species differ considerably from one another in characters of both imaginal and nymphal stages.

The genus Pseudocloeon Klapalek was described (**12**) from material collected in Java. The type species is *P. kraepelini* Klap., of which the female imago and the nymph are unknown. Figures of the legs and genitalia of the male of this species are presented by Dr. Ulmer (**23**), along with descriptions and figures of two other species of the same genus. Imagos which correspond to the generic characterization of Pseudocloeon occur commonly in the Nearctic fauna, and several species of these have been reared from nymphs by Drs. McDunnough (**14**) and Ide (**10**). These nymphs have but two tails; both labial and maxillary palps are two-jointed; gills single on all segments; claws pectinate. The two-jointed condition of the labial palp is somewhat deceptive, however, as there are some specimens from North Carolina 3(**19**) in which the fusion of the two distal joints into one is incomplete the palp thus appearing to be three-jointed. In the Cornell University collection, there are several specimens of Baetine nymphs taken in the Philippine Islands which are two-tailed; maxillary palp two-jointed; labial palp more or less distinctly three-jointed, claws pectinate; gills single. These accord well with the reared Nearctic nymphs heretofore assigned to Pseudo-

cloeon. Thus, although the type species of the genus has not been reared, nymphs which correspond to reared Nearctic nymphs are known to occur in the same faunal region as the type locality; imagos of these Nearctic nymphs agree well with the characterization of the genus Pseudocloeon. Until the type species has been reared, I propose to consider the nymphs described from the Nearctic region as representatives of the true Pseudocloeon.

South American nymphs described by Needham and Murphy (**16**) as presumably of the genus Pseudocloeon, prove on further examination to possess hind wing buds; these may be allies of Centroptilum. The nymph of a species described in Pseudocloeon has been recorded from South Africa by Barnard (**2**). This nymph has single gills, present on segments 2–7 only; both maxillary and labial palps are three-jointed; tails three in number, the middle tail somewhat shorter than the laterals. These nymphal characters, together with a tendency in the female imago for the marginal intercalaries to occur singly, (as in the Puerto Rican specimens), leads me to believe that the South African species is not a true Pseudocloeon, but an unnamed genus of the Pseudocloeon group. Another allied genus of this group is Baetiella Ueno (**21**). The nymph of the type species, *B. japonica* Iman., described in Acentrella 4(**11**), was previously described and figured by Ueno 5(**20**) as *? Acentrella sp.* It differs from described Nearctic species of Pseudocloeon only in the possession of a long, slender, filament or hair near the tip of the claw. The imago seems to accord well with the characterization given for Pseudocloeon. Other characters mentioned as separating this genus from allied genera do not seem to be distinctive of Baetiella. Is Baetiella worthy of generic rank?

Structural differences between nymphs from the several localities mentioned, are summarized in the following tabulation. Gills single; on 1–7, unless indicated.

Locality represented	Claws	Max. palp	Lab. palp	Tails
Philippine [1]........	Pectinate.........	2 jts.	3 jts.	2
Nearctic...........	Pectinate.........	2 jts.	2 (3) jts.	2
South African [2]....	?	2 jts.	3 jts.	3
Puerto Rican [3].....	Not pectinate [5]....	2 jts.	2 (3) jts.	3
Japanese [4].........	Pectinate.........	2 jts.	3 jts.	2

1—Nymphs in Cornell University collection; no published description.
2—Middle tail slightly shorter than laterals; gills present on segments 2-7 only.
3—Middle tail slightly shorter than laterals, in two species; much shorter, in third species.
4—Genus Baetiella. Long, slender filament near tip of claw.
5—Pectinate, in the aberrant species with very short middle tail; this probably does not belong in the same group with the other two species from Puerto Rico.

The nymphs of two of the Puerto Rican species are seen to differ from all the others in the absence of pectinations on the claws. These nymphs possess three tails, the middle one of these being slightly shorter than the laterals. In still another Puerto Rican species, represented by nymphs only, the claws are pectinate, the middle tail much shorter than the laterals, as in typical Baetis; this latter species is probably not congeneric with the other two, but is here treated tentatively under the same generic name. Since the Puerto Rican species differ so markedly from the Nearctic, Palearctic and Oriental species known, in the nymphal characters of tails and claws, it seems best to place them in a new genus, designated as Cloeodes *gen. nov.* This genus evidently does not include the South African species, which belongs in still a different category.

Genus **Cloeodes** gen. nov.

Turbinate eyes of male extraordinarily large, set on rather high stalks (fig. 20). Eyes of female larger, and set higher and closer together, than in Nearctic representatives of Pseudocloeon. Posterior margin of head of female distinctly emarginate. Fore leg of male only slightly shorter than body. Basal joint of fore tarsus of male very short; second joint longest, about equal to third and fourth combined. In decreasing length, tarsal joints rank: 2, 3, 4, 5, 1. Tarsus almost as long as tibia, which is almost twice the length of the femur. On middle and hind legs of both sexes, basal joint of tarsus very long, exceeding in length the three succeeding joints combined; this joint fully half as long as tibia on middle leg, more than half the length of the hind tibia (figs. 45, 45 A.). Tibio-tarsal joining indistinct. Hind wings absent. Marginal intercalaries of fore wing occur in pairs, which in male are well developed; in female, one member of a pair often indistinct or wholly wanting, so that some marginal spaces have but one intercalary. Cross veins arranged in three irregular series across wing: 6 in apical series, about 12 in middle series. Posterior margin of pronotum almost straight. Apical margin of sternite 9 in female *not* produced backward to form a subanal plate. Genitalia of male as in figure 13. A dome-shaped or slightly truncate "penis cover" is present between the bases of the forceps.

Genotype—**Cloeodes maculipes** sp. nov.

The genus is characterized from the type species. Other species placed in this new genus (*portoricensis, consignatus* and *sp.*) do not agree with the type as to the unusual length of the basal tarsal joint on the middle and hind legs, but conform rather to the type of Pseudocloeon in this respect. The nymphs of *consignatus* and *C. sp.* are unknown; nymphs of *C. portoricensis* are very similar to those of *C. maculipes.* Do *consignatus* and *C. sp.* represent still another genus? And what of *portoricensis?*

Key to Puerto Rican Species of Cloeodes

IMAGOS

1. Narrow longitudinal lines on femora and tibiae, dark spots at apices of fore femur and tibiae; wing 5½ mm. in length .... *maculipes*
   Legs without distinct markings; smaller species, wing 3–4½ mm. in length *2*
2. Wing (female) 4½ mm. in length; no marginal intercalaries in first interspaces .... *sp.*
   Wing 3–3½ mm. in length; marginal intercalaries in first two interspaces variable *3*
3. No marginal intercalaries in first three interspaces; abdominal tergites of female with prominent, lateral, purplish red, spots; male not known .... *consignatus*
   Marginal intercalaries usually present, though short, in second interspace; abdominal tergites of male and female largely pale, with no such purplish red, lateral, patches .... *portoricensis*

NYMPHS

1. All three tails approximately equal in length, not dark-banded; claws not pectinate *2*
   Middle tail slightly more than one half as long as laterals; tails marked with two dark bands; claws pectinate .... *sp. No. 1*
2. Small species, body 3–4 mm. in length; labial palp 2-jointed, distal joint as in figure 24 .... *portoricensis*
   Larger species, body 5 mm. in length; labial palp 3-jointed, distal joint conical, as in figure 19 .... *maculipes*

Cloeodes maculipes sp. nov.

A creamy white species, with distinctive black markings on femora and tibiae.

Male imago.—Body 5 mm.; wing 5½ mm.

Turbinate eyes very large, set on rather high stalks; upper surfaces almost circular (fig. 20). Stalk deep orange, upper surface pale orange. Head creamy white; faint blackish shading on median line ventrad of lateral ocelli. A broken, reddish, ring at base of antenna; basal antennal joint white; base of filament reddish black, remainder silvery white. Thorax opaque whitish, meso- and metathorax with faint pinkish tinge. Faint brownish markings on antero-lateral areas of mesonotum; scutellum alabaster white. A short, black, mark laterally, directly above base of wing; faint smoky pencilings on pleura, along courses of tracheae. An olive-brown, transverse, band on mesosternum, between middle legs, traces of a similar band on prosternum; ventrad of hind legs, on metasternum, a narrower, blackish, streak.

Legs creamy white; femora and apical portion of tarsi tinged with yellowish. A narrow, black, hair-line extends the length of each femur, on inner surface; a small, reddish, black basal spot on upper surface and a larger pre-apical one on inner surface; on fore femur, a small red-brown spot at apex.

A narrow, red-brown, line extends the length of the fore tibia; at the apex is a small black spot. Two longitudinal, black, dashes on middle and hind tibiae, one near base, one at center (fig. 45). Tibio-tarsal joining black. Wings hyaline; venation light brown, paler in the wing disc. Subcosta and radius dark brown at extreme base. Paired marginal intercalaries distinct. Cross veins arranged in three irregular series across wing; none near margin. Stigmatic cross veins 3 or 4 in number, simple, somewhat aslant; white next to subcosta, so that they appear incomplete.

Abdomen creamy white. Segments 2–6, also sternites 1 and 7, semi-translucent; tergite 1, and segments 8–10, largely opaque. A narrow, dark, red-brown, line marks the posterior margin of each tergite. Posterior margins of sternites opaque, but not darkened. A black line follows the tracheal trunk above pleural fold on each side; short, lateral, branches extend in both directions from this line. Tails silvery white; in proximal half, joinings narrowly purple-brown, alternately wide and narrow at extreme base. Genitalia as in figure 13. It should be noted that the genitalia of the paratype seem to possess a backwardly-directed truncate process between the bases of the forceps; in the holotype this process is lower and somewhat dome-shaped. Genitalia of both specimens were treated in potash before mounting.

Female imago—Body 5 mm.; wings 5½ mm.

Head and thorax light yellowish brown. A reddish black spot at apex of basal joint of antenna; apical margin of second joint similar in color; both of these joints yellowish. Antennal filament dusky brown, black at base. V-shaped maroon mark on vertex, above median ocellus. Two wide, purplish red, submedian, stripes extend from lateral ocellus to posterior margin of head. Eyes blackish. Posterior margin of pronotum black; purplish red markings consist of: antero-median triangle; small submedian dots; lateral markings, about four on each side. A wide purplish red streak on prothorax behind fore leg; this extends forward on to the coxa; a transverse band between legs, on sternum. On mesothorax, a broken band of purplish red extends forward from wing roots, to anterior margin of mesonotum; below this, at anterior margin, a shorter band of same color; from wing roots to base of middle leg, a longer band. Reddish markings also, around leg bases; laterally on mesosternum; a transverse band across sternum, between middle legs. Ruddy shading on each side of scutellum. Tip of scutellum yellowish. Spine-like process of metanotum purplish red, likewise streaks extending laterad from it. Purplish markings around leg base; a transverse band on sternum, between hind legs.

Legs yellowish. Each femur marked with a basal cross-band of purplish red on upper surface, and a pre-apical band of same color on lower surface. Tibiae marked as in male. Tarsi pale brownish in apical half; joinings narrowly darker. Costal margin of wing, to humeral cross vein, and bases of subcosta and radius, deep purplish red. All veins, and outer margin of wing, brownish; cross veins heavier than longitudinals; 4 or 5 stigmatic cross veins, slightly aslant. Marginal intercalaries as indicated in account of genus.

Abdominal segments 2–7 semi-hyaline, yellowish with extensive purplish red markings; segments 8–10 opaque, heavily shaded with reddish. Posterior margins of all tergites with a wide purplish band; this band reduced to a narrow line on tergites 3 and 4. Tergite 2 largely purplish; a small, pale, spot at median area of posterior margin; lateral pale area next to pleural fold. Me-

dian areas of tergites 3 and 4 almost wholly pale. On tergites 2–7, a wide, oblique, lateral, stripe, deep purplish red in color, extends the length of the segment (on 4, this may be indistinct in posterior half). Pale areas laterally, on all tergites, next to pleural fold; a blackish line follows course of tracheae the length of the abdomen. Sternite 9 yellowish; sternites 6–8 overlaid with red shading. Sternites 1–5 pale yellowish; wedge-shaped, purplish, markings in postero-lateral areas of sternite 1 and 2; traces of same, on sternite 3. Tails missing, except a few basal joints. The two basal joints shaded with purplish red, next two yellowish; wide black band at each joining.

Nymph—(described from slough of type specimen, with additional notes from nearly-matured nymphs).

Head brown, with pale markings. Antennae whitish, at least basally. Pale markings on median and lateral areas of frons: a pale band between eyes and bases of antennae; median line of vertex pale. Maxillary palp 2-jointed, apparently without hairs or spines (fig. 29). Labial palp 3-jointed; distal joint conical at apex (fig. 27). Thoracic notum smoky brown; pale markings on mesonotum anterior to wing roots, the median line pale. Pleura and sternum pale; the former with prominent dark brown semi-lunar markings above base of each leg. Coxa and trochanter pale, often a brown band across coxa. Femur brownish, with wide, pale, longitudinal, streaks at base and apex. Tibia and tarsus pale smoky; in certain lights, a dark, median, band is seen on tibia. All joinings narrowly darker brown. Claws without pectinations. Abdominal tergite 8 largely yellowish; tergites 4 and 7, and basal half of 9, yellowish with brown markings. Other tergites smoky brown; 5, 6, and apical half of 9 often darker than basal ones. A pair of minute, pale, dots at median line, near center of segment, on tergites 1 to 3. Sternites paler than tergites, usually yellowish, more or less distinctly brown-tinged. Brownish shading near pleural fold; posterior margins often narrowly brown. Gills present on segments 1–7; simple, obovate (fig. 42). Tracheation pinnate; blackish, very distinct. Tails three, the middle one only slightly shorter than the laterals; yellowish brown without darker markings. Tufts of very short hairs on each segment (on both sides of middle tail, on inner side only of laterals) appear like stubby bristles.

Length: body 5 mm.; tails 2 mm.

Holotype—Male imago, reared from nymph; Luquillo Mts., P. R., June 14, 1935 (J. García-Díaz). No. 1402.1 in Cornell University collection.

Allotype—Female imago, Trout's pool, El Yunque Trail, Luquillo Mts., P. R. June 12, 1935 (J. García-Díaz). No. 1402.2 in Cornell University collection.

Paratype—Male imago, reared; same data. No. 1402.3 in Cornell collection.

Nearly-mature nymphs of this species were taken during 1935 (J. García-Díaz) in the Sabana River and the Hicaco River, Río Blanco (Mch. 7); in La Coca Creek, the Luquillo Mts. (May 26); and at Guajataca Creek (Mch. 22).

Cloeodes portoricensis sp. nov.

Thorax and tip of abdomen dark red-brown; middle abdominal segments hyaline, white.

Male imago.—Body 3–3½ mm.; wing 3½ mm.

Head red-brown; antennae faintly tinged with reddish. Turbinate eyes very large, prominent; upper surface oval; orange-brown in color, outer rim of upper surface dark brown. Thorax dark red-brown. Mesonotal scutellum and a small spot on each side of it, alabaster white; a similar white patch on scutellum of metanotum. Light tan markings on pleura, near sutures. Legs wholly pale, whitish. Wings hyaline; cross veins practically invisible. Costa, subcosta and radius reddish brown at extreme base; a small brown spot at base of wing. Stigmatic cross veins 4 to 6 in number, simple, somewhat aslant, often incomplete except at the costal margin. Granulations in stigmatic area, extending over apical portions of costal and subcostal spaces, give appearance of a milky cloud. No intercalaries in first interspace; 1 or 2 may be present in second interspace, very weakly developed; in remaining spaces, well developed but rather short.

Abdominal segments 2–6 hyaline, white; joinings opaque. A double, blackish, wavy, line extends along the spiracular area of tergites; a tiny, dark, dot on each line, at spiracle. Tergites 7–10 dark red-brown, but somewhat brighter and paler than thorax. Sternites 7–9 creamy white, faintly tinged with brownish, especially near pleural fold. Tails silvery white. Genitalia as in figure 6.

Holotype—Male imago; Lares, P. R., March 23, 1935 (J. G. Needham, J. García-Díaz). No. 1401.1 in Cornell University collection.

Paratype—21 male imagos, same data. No. 1401.3–20 in Cornell collection.

Seven female imagos, taken in the Luquillo Mts. on Feb. 18, 1935, by the same collectors, may be of this species. Body flesh-colored, head and mesonotum paler than abdomen and remainder of thorax. Abdominal tergites rose-tinged; posterior margins of segments purplish rose on each side of pleural fold, not elsewhere. Longitudinal veins faintly brownish. Othewise similar to males.

Sub mago males were taken at Lares, the Guajataca River, on March 22, 1935 (J. G. Needham, J. García-Díaz). The following day, one male and several female subimagos were captured at Adjuntas, (J. García-Díaz).

One male imago was reared, thus making it possible to correlate the imagos with certain strikingly-colored nymphs which had been taken at several stations.

Nymph—Head yellow; faint brown shading on vertex and occiput on each side of pale median line, also above antennae and median ocellus. Antennae pale, faintly darker at joinings. Maxillary palp two-jointed (fig. 30); labial

palp two-jointed, the distal joint expanded into a lobe on the inner margin and terminating in a sharp point (fig. 28). Thoracic notum yellowish brown with darker markings in female, darker brown with pale markings in mature male. A well-marked male show a pale thoracic median line; yellow submedian blotches on posterior margin of pronotum; a trident-shaped pale marking at middle of mesonotum, the points directed forward; a pale band across the scutellum; large, diffuse, yellow, markings between the wing pads, and a few small spots anterior to wing roots. In some specimens, the arms of the pale trident become much widened, so that a large area on each side of center of mesonotum is yellow. Pleura and sternum yellowish. Prominent dark brown semi-lunar markings above bases of legs, and a small, dark, median, spot on anterior portion of mesosternum. Dark, median, and lateral, patches on metanotum. Legs yellow. A small, dark brown, "knee spot" and similar dark spot at tip of tarsus; other joinings narrowly darker. Claws not pectinate.

Abdominal tergites 1, 4, 8 and 10 almost wholly yellowish; tergite 5 yellowish in median area, brown laterally; remaining tergites largely brown, except for round, yellow, median, spot on 2, 3 and 6. Crescentic brown mark on anterior portion of tergite 4; similar but wider mark on 10. Posterior margins of all tergites narrowly dark brown; a small, dark, mark at base of each gill. Sternites pale yellowish; posterior margins of apical segments very narrowly brown. Gills single, obovate, broadly rounded at free end; tracheation pinnate (fig. 43). Tracheae greyish purple, rather indistinct; main trunk often forked near tip, lateral branches few and weak. Tails three, approximately equal in length and thickness. Whitish, with an amber tinge which becomes deeper toward apex. Joinings opaque, faintly amber.

Length: body 3–4 mm.; tails 1½–2 mm.

Specimens of this species were collected during 1935 (J. G. Needham, J. García-Díaz) at the following places: Lares, Guajataca Creek, Mch. 22; Quebrada Tomey, Feb. 21; Río Cidra, Adjuntas, Mch. 24; Utuado Road, Mch. 13; and Hicaco River, Mch. 7.

Cloeodes consignatus sp. nov.

Female imago.—Body 3½ mm.; wing 3 mm.

Head largely suffused with purplish red. Thorax creamy yellow. Lateral and anterior areas of pronotum with extensive purplish red-markings; pleura largely purplish red. Scutella of meso- and metanota, and all elevations of notum, alabaster white. Sternum yellowish with alabaster white markings laterally. Fore and middle legs missing. Hind legs very pale yellow, unmarked. Wings hyaline; longitudinal veins very pale amber; a small, purplish red, spot on humeral cross vein, and brown shading at extreme base of costa, subcosta, and radius. No marginal intercalaries in first three interspaces; none in any space beyond media, usually a single intercalary only in spaces between branches of media; elsewhere intercalaries are normal, paired. Stigmatic cross veins 4 to 5 in number, strongly aslant, usually incomplete toward costa. Abdomen white; segments 1–7 hyaline, 8–10 semi-opaque with distinct yellow tinge. A faint, blackish, double, line extends the length of the spiracular area.

Above this, on each tergite, a prominent rhomboidal purplish red spot; below it, on each sternite, a curved, purplish red mark. Tails missing.

Holotype—Female imago; Yunez River, P. R., June 21, 1935 (J. García Díaz). No. 1403.1 in Cornell University collection.

Cloeodes sp.

Female imago.—Body shrunken; wing 4½ mm.

Head yellowish; posterior margin blackish. Antennae yellow; joinings of basal segments reddish. Thorax yellowish, shaded rather heavily with reddish on pronotum and pleura. Legs yellowish white, unmarked. Wings hyaline, venation very pale brown. Humeral cross vein, extreme basal portions of costa, subcosta and radius, and small area at base of middle veins, reddish brown. Stigmatic cross veins 3 or 4 in number, aslant. No marginal intercalaries in first two interspaces; behind media these intercalaries single or absent. Abdomen heavily shaded with reddish, except middle of venter and dorsum, which are yellowish, hyaline; posterior margins of tergites, and of sternites near pleural fold, reddish black. Two black lines extend the length of the pleural fold. Tails missing.

Taken in Luquillo Mts., P. R., Feb. 18, 1935 (J. G. Needham, J. García-Díaz). It is quite possible that this is the female of *C. portoricensis*, rather than the paler specimens taken on the same date, which are briefly described under that species.

?? Cloeodes sp. No. 1

Nymphs which superficially resemble those of *Baetis garcianus*, but with hind wing buds wholly lacking, and distal joint of labial palp lobed, as in figure 16. Probably do not belong in this genus.

Nymph.—Head pale reddish brown; median line of vertex and occiput, and epicranial suture, faintly pale; a dark brown spot on each of first two basal joints of antenna. Maxillary palp two-jointed (fig. 31); labial palp likewise two-jointed, distal joint mitten-shaped, as in figure 26. Thoracic notum light reddish brown, median line paler; indistinct, paler, markings laterally on pronotum, and on mesonotum anterior to wing roots. Pleura and sternum paler than notum; dark areas on pleura above leg bases. Legs yellowish. Femora faintly tinged with smoky, and with a brown spot at apex; claws pectinate. Abdominal tergites quite uniformly light red-brown, somewhat paler next to pleural fold; in some specimens, tergites 9 and 10 are slightly paler. Intersegmental areas yellowish. Posterior margins dark brown; postero-lateral angles shaded with smoky brown, and with a dark dash at base of each gill. Indistinct, paler, markings are visible on some specimens, as follows: anterior portion of median line; spot on anterior margin halfway between median line and pleural fold; round, submedian, spot on each side, at about center of tergite. Two short, dark, transverse, dashes on anterior margin, one on each side of median line. Sternites somewhat paler than tergites; on each, a narrow,

dark, transverse, line on anterior margin, in median area only. A distinct, dark, spot at each spiracle, and a dark line leading forward from this to anterior margin, are faintly seen from dorsal view, but are much more evident on ventral surface. Gills single, obovate, intermediate ones asymmetrical as in *Baetis garcianus,* but slightly longer and less rounded at apex. Tracheation pinnate, very indistinct; only the basal portion of main trunk is clearly evident. Tails three; yellowish, crossed by two prominent black bands, the distal of these being the wider. Middle tail slightly more than half as long as the laterals.

Length: body 4–5 mm.; tails 3 mm.

Specimens of this species were taken during 1935 (J. G. Needham, J. García-Díaz) at Utuado Road (Mch. 13); Río Blanco (Mch. 6); La Joba Creek at Río Blanco (Mch. 8); Cagüitas River (Mch. 4); Carreres River (Mch. 9); small creek near Jayuya Road (Mch. 24); and the Luquillo Mts. (Feb. 18, May 26).

Cornell University, Nov. 30, 1936.

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EXPLANATION OF PLATES

PLATE I

Fig. 1.—*Neohagenulus julio.* Male imago; wings.

Fig. 2.—*Borinquena carmencita.* Female imago; tip of abdomen, showing long ovipositor.

Fig. 3.—*Neohagenulus julio.* Male imago; genitalia.

Fig. 4.—*Borinquena carmencita.* Male imago; wings.

Fig. 5.—*Baetis garcianus.* Male imago; genitalia.

Fig. 6.—*Cloeodes portoricensis.* Male imago; genitalia.

Fig. 7.—*Neohagenulus tinctus.* Female imago; tip of abdomen, ventral aspect, showing egg valve and subanal plate.

Fig. 8.—*Borinquena carmencita.* Male imago; forceps base and portion of basal joint of forceps.

Fig. 9.—*Baetis garcianus.* Male imago; hind wing.

Fig. 10.—*Borinquena carmencita.* Male imago; hind wing.

Fig. 11.—*Neohagenulus julio.* Male imago; hind wing.

Fig. 12.—*Borinquena carmencita.* Male imago; genitalia.

Fig. 13.—*Cloeodes maculipes.* Male imago; genitalia.

PLATE II

Fig. 14.—*Neohagenulus julio.* Nymph; tibia of third leg.

Fig. 15.—*Neohagenulus luteolus.* Nymph; tibia of third leg.

Fig. 16.—*Neohagenulus julio.* Nymph; femur of fore leg.

Fig. 17.—*Neohagenulus luteolus.* Nymph; femur of fore leg.

Fig. 18.—*Neohagenulus luteolus.* Nymph ; gill from third abdominal segment.

Fig. 19.—*Borinquena carmencita.* Nymph; gill from third abdominal segment.

Fig. 20.—*Cloeodes maculipes.* Male imago; lateral view of head.

Fig. 21.—*Neohagenulus julio.* Male imago; lateral view of head.

Fig. 22.—*Borinquena carmencita.* Male imago; lateral view of head.

Fig. 23.—*Baetis garcianus.* Nymph; gill from fourth abdominal segment.

Fig. 24.—*Baetis sp. No. 1.* Nymph; gill from fourth abdominal segment.

Fig. 25.—*Baetis sp. No. 1.* Nymph; labial palp.

Fig. 26.—? *Cloeodes sp. No. 1.* Nymph; labial palp.

Fig. 27.—*Cloeodes maculipes.* Nymph; labial palp.

Fig. 28.—*Cloeodes portoricensis.* Nymph; labial palp.

Fig. 29.—*Cloeodes maculipes.* Nymph; maxillary palp.
Fig. 30.—*Cloeodes portoricensis.* Nymph; maxillary palp.
Fig. 31.—? *Cloeodes sp. No. 1.*—Nymph; maxillary palp.

Plate III

Fig. 32.—*Borinquena carmencita.* Nymph; labium.

Fig. 33.—*Borinquena contradicens.* Nymph; detail of canines of mandible.

Fig. 34.—*Borinquena contradicens.* Female subimago; tip of abdomen, lateral view. Ovipositor somewhat flattened out.

Fig. 35.—*Borinquena contradicens.* Nymph; maxilla.

Fig. 36.—*Borinquena contradicens.* Male imago; penes, enlarged.

Fig. 37.—*Borinquena carmencita.* Male imago; tip of abdomen, lateral aspect, showing the very long forceps. One tail omitted.

Fig. 38.—*Borinquena contradicens.* Nymph; hypopharynx.

Fig. 39.—*Borinquena contradicens.* Nymph; gill from third abdominal segment.

Fig. 40.—*Borinquena contradicens.* Nymph; labrum.

Fig. 41.—*Borinquena contradicens.* Male imago; genitalia.

Fig. 42.—*Cloeodes maculipes.* Nymph; gills of second and third abdominal segments; showing abdominal segments three, four, and five.

Fig. 43.—*Cloeodes portoricensis.* Nymph; gills of second, third, and fourth abdominal segments; showing abdominal segments three to seven.

Fig. 44.—*Neohagenulus julio.* Male imago; penes, enlarged, one side distorted, showing what appears to be long, slender, spine on inner margin.

Fig. 45.—*Cloeodes maculipes.* Male imago; third leg. A; same, enlarged.

Fig. 46.—*Neohagenulus luteolus.* Nymph; claw of fore leg.

Fig. 47.—*Neohagenulus luteolus.* Female imago; hind wing.

Fig. 48.—*Neohagenulus luteolus.* Nymph; labium.

Fig. 49.—*Neohagenulus luteolus.* Nymph; mandible.

Fig. 50.—*Borinquena contradicens.* Male imago; hind wing. B; same species, female subimago, showing tip of wing folded over.

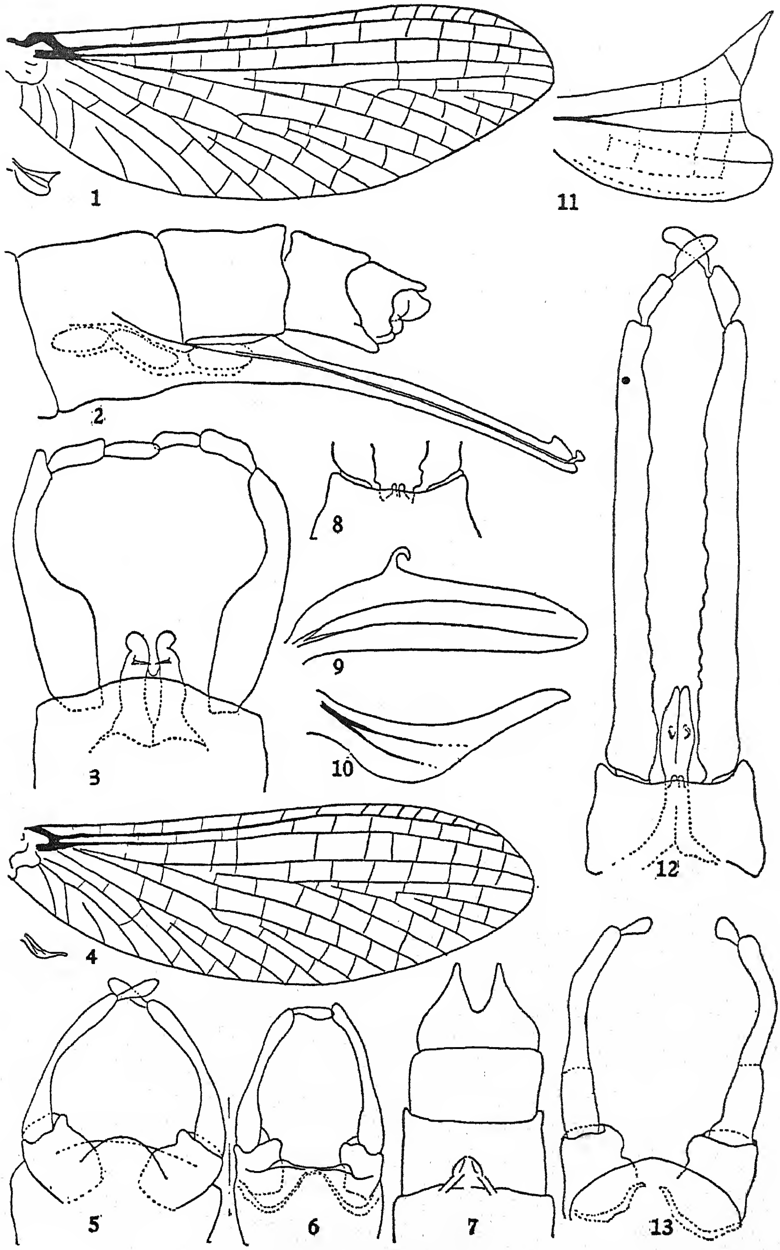
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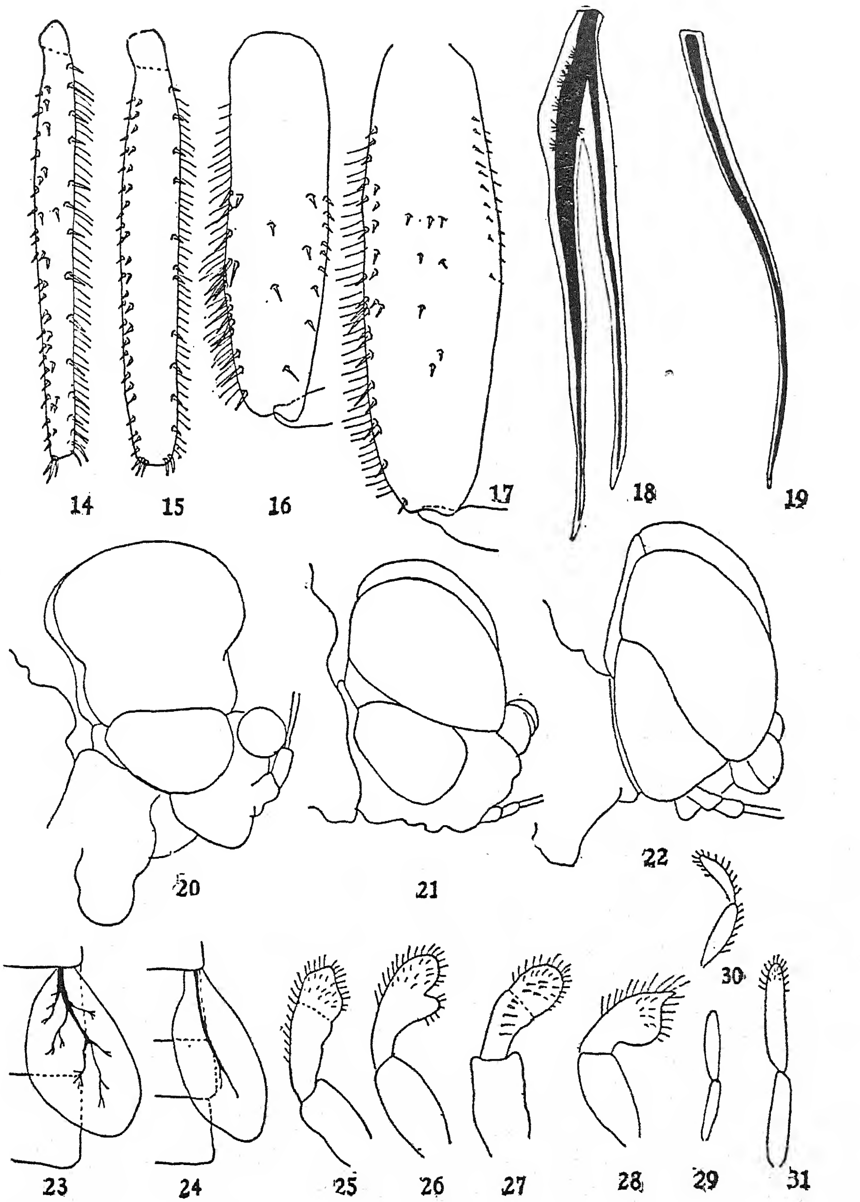
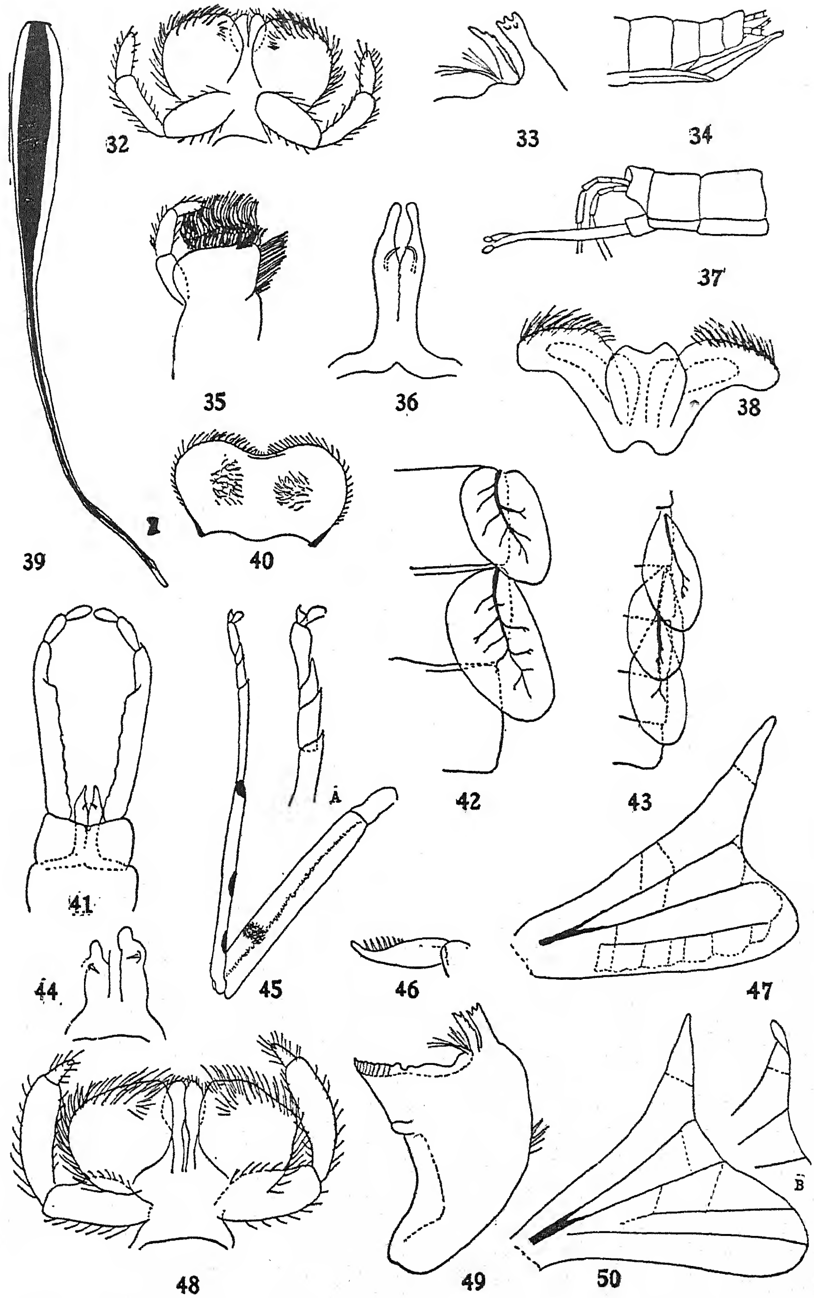
PLATE II

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AN ECOLOGICAL SURVEY OF THE FRESH WATER INSECTS OF PUERTO RICO *

1. THE ODONATA: WITH NEW LIFE-HISTORIES

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Very little intensive work has been done in the fresh water fauna of the Island. The Fish Commission Expedition to Puerto Rico in 1900 said: ". . . An examination of the literature pertaining to the Natural History of the West Indies showed that comparatively little was known concerning the fishes, and scarcely anything of the other aquatic animals or of its aquatic flora." Although the conditions at present are not so critical in the entomological field because of the work of Howard, Dyar and Knab (1912), Dyar (1928), Curran (1928) (1931), Leng and Mutchler (1914) (1917), Barber (1923) and Needham and Fisher (1936), who included in their publications the aquatic insects belonging to the groups discussed; as well as the articles published by other authors like Tower (1912) (1921), Hoffman (1925), Root (1929), Earle (1930), Wells (1930), Bradt (1932) and others, the aquatic insects of the Island are far from well known. Two other workers, Klots (1932) and Alexander (1933) have contributed greatly to the knowledge of the insect aquatic fauna. Alexander states in his paper that the reduced number of species must be due to lack of collecting rather than to the scarcity of species. His contention has been corroborated by the material he most kindly determined and shown in appendix A. A glance through this, which shows the determinations made up to the present time by the specialists to whom material has been submitted, supports also the statement made before.

In spite of the small size of the Island its fresh waters harbor species of all the phyla which in similar environments occur over the world. Protozoans, coelenterates, platyhelminthes, nemathelminthes, annelids, molluscs, arthropods and vertebrates, all of them, in their adult or developmental stages have representatives in the different fresh water habitats of the Island. Among the aquatic insects there are members of all orders having them, with the only possible excep-

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tion of the Plecoptera. Very striking is the apparent absence of these, which must be attributed to their impossibilty, beng poor flyers, to reach the Island. This seems to be the only factor because places where they could live are plenty all over.

The habitats for all these species vary greatly, from the rapid, turbulent flow of the rivers in the higher levels of the Island, through the slow moving courses of the same along the coastal plains to the few small standing lakes, lagoons, pools and marshes.

Puerto Rico has been called the land of the rivers, possibly rightly so, if one considers that on its 3,500 square miles there are about 1,500 streams although not all of them are really rivers. The majority are tributaries to about 80 or 100 larger ones. The high altitude of the mountains, attaining heights of over 4,000 feet, when taken in consideration to the width of the Island which is only about 35 miles, make these rivers exceedingly rapid when cutting their way through the gorges of the central mountains range. The placing of the chain of mountains (Fig. 2), which has been secondarily determined by erosion as shown by Meyerhoff (1933), about two thirds away from the northern coast, has a decisive influence upon the nature of the rivers. Rainfall, due to the placing of the mountains in relation to the prevailing winds during the year, is most common on the north side where it may attain a maximum of 140 inches on Mt. El Yunque. Corresponding areas on the southern slope may get only 100 inches and sometimes go through periods of drouth. Thus the rivers which flow into the north and west have longer courses and are less rapid than those on the southern and eastern side. The longest river of the first group may attain a length of 40 miles while the corresponding one of the southern side would be less than half that length. The northern rivers usually have a permanent flow of water while those on the opposite side may dry up completely during sometime in the year. The beds of these rivers vary greatly. There are some rocky ones with practially no loose stones in them high up in the mountains; others are gravelly with small and medium sized boulders along their middle courses and lastly that portion close to their mouths where sandy and silty bottoms are found. The beds of those on the southern slopes, although similar to the ones last mentioned, are more rocky and the boulders are more common in them.

To the mechanical and climatological factors determining the nature of the rivers has to be added the influence brought about by the altering of natural conditions through human activity. The Island being heavily populated has been completely deprived of most

of its natural forests. So a few hours of rainfall may cause the rivers to swell and small streams of water soon become imposing torrents. But with the same rapidness with which they swell do they return to their normal volumes. This rapid run-off washes into the rivers considerable amounts of silt and mud. Because of this, although at the higher levels the water soon becomes clear and transparent, in the lower places it may remain muddy for days of even weeks, depending on the duration of the rain. This mud has settled and filled the bottoms of some rivers which are no longer navigable to small boats as they used to be. This sudden variation in volume of the rivers is nicely shown in their beds which usually are dual in nature. The one where the river normally and continually runs and a wider one marked by the effects of the rushing waters during the floods. Sometimes during this period water is left along the edges of the rivers in the lower lands and holes close to them, and pools and marshes, some temporary others permanent, are formed. Upon reaching the sea the tide tends to keep them back and part of their course, for some distance up, is rendered more or less brackish.

The plant life occuring in the rivers and along their edges and serving as food for the vegetable feeders varies at different levels. High up in the mountains are found very few plants: only the algae, desmids and diatoms which are capable of clinging to the rocks in the swift running waters; in the slower running ones on wet stones and along the edges, are found the mosses and liverworts together with some ferns and higher aquatic plants. Lower down in the less rapid waters the most common and easily seen aquatic plant is Potamogeton besides the algae and lower forms, and along the edges are most commonly found "Malojillo", *Panicum* sp., *Polygonum* sp., and sedges and rushes; close to their mouths, where there is a very sluggish flow, the "flor de agua" *Castalia ampla* Salisb. makes its way farthest toward the center of the river, while farther back along the edges and marshy places the cat-tails *Typha angustifolia* L. and taller sedges like *Mariscus jamaicensis* (Crants) Britton and other smaller ones are seen together with other aquatic and semi-aquatic plants.

There are no true lakes on the Island. The only one which approaches this type of body of water is the one near Manatí called Tortuguero Lake. It occupies an area of 4 by 1½ kilometers, has no permanent inflow of water and fills up only during the rainy season from the waters of the nearby small hills called "mogotes". It is subject to great variations in its level, although it has never been known to dry up completely. I have seen its west end entirely

dry in August and walked along places where it would have been impossible to do it in March when Doctor Needham and I collected at the extreme west end. The shore line on its southern side had receded no less than 25 feet from the original one where collecting had been done during February and March. Notwithstanding its variations, aquatic insect life is always abundant along the shore. The lake has no natural connection with the sea and although very close to it, its waters are fresh. There is the possible exception of those of its northern shore where collecting of insects forms was remarkably poor compared with the southern shore. Possibly the wind and a certain degree of brackishness were responsible for this. There are two pipes leading from the lake to the sea by means of which it is drained when the water level gets too high. The aquatic plants which occur in it and along its shores and serve as food and shelter to aquatic insects have been discussed by Cook (1928). A sphagnum, *S. cuspidatum* var. *serrulatum* Schlisph, kindly determined by Dr. LeRoy Andrews, was found by Doctor Needham along the southern shore of the lake.

The next larger body of water approaching a lake is Cartagena Lagoon. It is much smaller in size than Tortuguero and as indicated by Danforth (1926) subject to wide variations in its water level. Cook (1928) also mentions this fact and states that in 1926 in a period of about two months the shore line had gone back about ten meters. There are records of it having dried up completely. Like Tortuguero it has not permanent inlet of water, neither an outlet. In cases when heavy rainfall fills it most completely Danforth (1926) says it overflows and the excess reaches the sea through the Boquerón river and its tributaries. The plant life found here is similar to the one of Tortuguero Lake and has been also discussed by Danforth and Cook. A remarkable difference in a species of the open water was that of *Nais* sp. which Danforth states in one instance nearly choked the lagoon. When Doctor Needham and I were there *Nais* was not so common but its place was ocupied by *Ceratophyllum* sp. which was very thick. Cartagena Lagoon like Tortuguero Lake, harbors a numerous fauna of aquatic insects as well as other fresh water forms.

There are a few, other smaller lagoons along the northern coast. Also those like that of Guánica and two smaller ones near Cabo Rojo. Some collecting was done in them but they do not seem to compare in any way to the larger two.

Swamps are most common along the northern shore. The largest one is Caño Tiburones between Arecibo and Barceloneta. Through

its natural outlet by way of Arecibo River; through the canal which has been opened at its east end and leads into the Manatí River, and through the many ditches and canals made trying to drain it as indicated by Cook (1926), a large area has been rendered salty. The waters are not fitted for all fresh aquatic insects and only the hardier ones seem to be found there. Very little or practically no collecting has been done here.

A peculiar and highly specialized fresh water habitat on the Island is represented by the sink holes near Isabela. A dry region, generally speaking, these sink holes which retain the water of the few showers, offer the only place for aquatic animals. Some of them, in August, were nearly dry, others completely choked with the "flor de agua" and "lechuguilla de agua" (*Pistia atratiotes* L.) while others had some water in them. All at the time mentioned, were very muddy and did not look very promising for collecting. Yet, they yielded heavily both in number of species and in individuals. Because of the nature of the surrounding country the water of these sink holes has a high alkalinity and possibly this may have some effect upon their inhabitants.

An additional habitat for the fresh water forms is the one offered by the irrigation systems developed in some parts of the Island. What is the nature of the forms living here I do not know since not much collecting has been done in them. I have collected mayflies, Baetinae, in a small, temporary system near Fajardo. If in such a small one as this mayflies were collected, there is no doubt that the more permanent ones of Isabela and Juana Díaz would certainly yield much more. Their importance in upsetting natural conditions through the agency of fresh water forms living in them has been pointed out by Earle (1925) (1930) who warned of the dangers of the extension of malaria on the Island due to the breeding of mosquitoes in the temporary pools formed in the irrigation ditches. Hoffman also believes they will be means for the distribution and spreading of Schistosomiasis as it may have happened already in Guayama and adjacent places, by offering breeding and living places for *Planorbis* sp., the snail which is the intermediate host of the latter disease.

With such a variety of environment in which to live, fresh water forms and thereby aquatic insects must be numerous. How has it been possible to miss, up to this time, some of them, is more than an usual happening which can be accounted for only by the absence of an intensive collecting. Mayflies, although not so common on the lowlands, are certainly numerous along the creeks in the higher areas

and no citation, but with only one exception, is found in current literature about the group. This is in strong contrast with the findings of Dr. J. R. Traver as shown in Appendix A.

The two hundred vials which contained the material collected by Dr. James G. Needham and myself during the months of February and March, together with those accumulated by me during periods of irregular collecting, when finally sorted turned into two thousand. From their contents have come out a number of additional records as well as additional new genera and species which I hope may be a stimulus to further the interest on the Island's fresh water fauna.

Interesting and important as is the determination of the existing species there still remains a no less during and satisfying phase of the work. Set in a peculiar environment, due to special physiographical and biological conditions together with the fight among themselves for food, shelter and ability to perpetuate their kind by means of reproduction, with the ensuing struggle for existence, each one of these groups has developed special means of meeting conditions for the aforesaid purpose. To study their occurrence, distribution, relationship and some of their adjustments and how they have developed is a most fascinating enterprise. The pages to follow are a most humble start in one of the groups. The discussion is based on part of the material collected by Dr. James G. Needham and myself. He not only determined the species but placed at my disposal the notes and records which he made during his stay on the Island and upon which I have drawn. For his wise counsel and many kindnesses during our long association, I will be always greatly obliged. A similar obligation and appreciation is herein expressed for all the specialists who have determined the material included under their names in Appendix A as well as to those others to whom some material has been submitted and is under way of determination. My thanks also to all others who in any direct or indirect way have helped me during my work. The drawings on plates IV, V and VI were done by Dr. Velma Knox, and the wings on plate VII were photographed by Mr. Archie Hess. To both of them my sincere thanks.

ODONATA

The dragonflies are among the insects most commonly seen in Puerto Rico. How Ledru (1810) failed completely to report in his list these insects is not understood. In any open space, along the many rivers on the Island, along the shores of the lakes, lagoons, or temporary pools fly these conspicuous forms of insect life. There are

some that are not so easily spotted due to their habits of keeping in shady places or else among the plants close to the bodies of water, which are easily missed unless specifically looked for.

The number of species, forty-three, herein discussed is considered small if compared with those of Cuba. Doctor Klots (1931) in her excellent paper on the Odonata of Porto Rico and the Virgin Islands attributes this reduced number to the scarcity of breeding places but "the fact of Cuba's longer association with the continental land mass and of Porto Rico's earlier isolation" should receive further consideration. This earlier isolation preventing the arrival of some forms, together with the subsidences and upliftings of Puerto Rico which brought changes in climate and habitats, these latter ones especially along the coast, may have been factors determining the odonate fauna. Extinction also through the action of the stronger odonates feeding upon the weaker, as well as destruction brought about by other animals, may have been deciding factors. Schmidt (1930) in discussing the amphibians and reptiles mentions some of the preceding factors, and although there is a great difference between these forms of animal life and insects, still there is a possibility of considering them. Taking in consideration the number and nature of the rivers on the Island, as well as lagoons and other swampy places, I think there are enough breeding places for supporting a larger number of species than those at present in existence. Puerto Rico, at least on its northern side, is amply supplied with rivers which do not dry up during the entire year and also there are a few lakes which could be used as breeding places. It is true that lakes are scarce and only one, Tortuguero Lake, has never been known to dry up, but the rivers with their rapid running waters high up in the mountains and their sluggish courses along the coastal plain could afford places to lotic and static species wherein to breed. Wilson (1911) while discussing the Odonata of Jamaica points out the influence of the nature of the rivers of the Island in keeping the majority of the species "confined to the immediate vicinity of the isolated ponds and quiet streams".

There is the possibility of the extinction of some of the species originally occurring on the Island. The case of *Protoneura capillaris* and *Leptobasis vacillans* failing to be collected together with all the other forms reported from the Island tends to show something along this line. This consideration is highly questionable since there is always the possibility of not having hit the places where these forms breed. A specimen of the former was collected in a house, flying to lights, in Hato Rey, near Río Piedras, by the author about

six years ago, but unluckily he failed to state definitely the date when caught and it was impossible to do it years afterward when the specimen was determined. No other specimens have been ever collected. This is also the case with *Leptobasis.*

Taking as a basis all available records, those published as well as those based on the collecting done by Doctor Needham and the author, a seasonal distribution of the Odonata of Puerto Rico has been considered. Fig. I shows this distribution. Taken as a whole there seems to be no seasonal distribution of the Odonata. There are extreme cases which tend to show the contrary, but a more intensive collecting and detailed observations in the biology and ecology of those forms may modify such views. Very little has been done along the ecology of these insects on the Island, most of the information available being only along strictly taxonomic lines. In the impossibility of formulating any reliable general statements the individual species will be discussed later, always condtioned by the need of further observation and more widely spread collecting. The maps, Fig. 3 and 4, showing the collecting places give the impression that the Island as a whole has been fairly covered. But in a majority of those placed no intensive collecting has been carried out and when this is done changes and modifications of present conditions are certain to crop out.

An altitudinal distribution of the forms was also tried as shown in Table II. As in the previous cases and for the same reason it is impossible to make general statements. The different species of *Anisoptera* upon which data are available may be grouped into four main divisions: (1) above 2,000 feet: *Macrothemis celeno* and *Scapanea frontalis.* Nymphs of *Dythemis rufinervis* have been collected also above this level. If a nymph collected in Buena Vista Camp in Maricao Forest Reserve is an *Aeschna,* as it is being assumed, there would have to be added to this group *Aeschna cornigera* which is the species reported from the Island. Adults of the latter have been collected in the next division. (2) Above 1,000 and up to 2,000 feet: *Aeschna cornigera, Anax junius, Dythemis refinervis, Erythrodiplax connata justiniana, Erythrodiplax umbrata, Lepthemis vesiculosa, Orthemis ferruginea, Tramea abdominalis,* and *Pantala flavescens.* (3) Above 500 and up to 1,000 feet: *Erythemis plebeja* and *Tramea binotata.* (4) From sea level up to 500 feet: *Brachymesia herbida, Cannacria furcata, Coryphaeschna adnexa, Erythrodiplax minuscula, Idiataphe cubensis, Miathyria marcella, Micrathyria aequalis, Micrathyria dissocians, Perithemis domitia* and *Tramea onusta.* Here should also be added *Anax amazili* known only from

the Island by its nymph and *Acanthagyna nervosa* of which there are no available records as to adult distribution,[1] but Doctor Klots' (1932) supposition of a nymph would place it in this group. If from group 3 and 4 are removed the two *Trameas* and placed in group 2 where the other occurring on the Island has been found and also *Coryphaeschna adnexa* which because of being a strong flier could easily go to higher levels, there would be a possibility of reducing all forms to two main divisions: those capable of trespassing the 1,000 feet level and the other below this altitude and possibly restricted to the coastal areas or lower levels of the Island.

In the Zygoptera, Table II, three main groups have been found: (1) Above 2,000 feet, *Telebasis vulnerata* is found. (2) From 1,000 to 2,000 feet with *Telebasis dominicanum* and *Enallagma civile* as adults plus *Enallagma coecum* and *Lestes forficula* as nymphs included. (3) From sea level up to 500 feet comprising *Anomalagrion hastatum*, *Argiallagma minutum*, *Ceratura capreola*, *Enallagma cultellatum*, *Ischnura ramburii*, *Lestes forficula*, *Lestes scalaris*, *Lestes spumarius*, and *Protoneura capillaris*. If from group three, as in Anisoptera, are removed the *Lestes* included, and *Enallagma cultellatum* placed arbitrarily with the other *Enallagmas*, there could be also two main divisions: those not trespassing the 500 feet and the ones going higher than the 1,000 feet level; the geographical regions corresponding to those indicated under Anisoptera.

Because dragonflies are strong fliers the altitudinal distribution of adults has not a great meaning unless it is correlated with the same distribution of their nymphal stages. The incomplete knowledge of distribution on the island of such stages makes impossible, except in individual cases later indicated, such correlation and the preceding discussion will be, no doubt, greatly modified as more data are accumulated.

Little could be said about the horizontal distribution of Odonata, especially along the lower levels, due to the ability of the adults to fly for very long distances. But there seems to be some forms which are strongly localized as shown by the collecting done up to the present time. Here would belong *Ceratura capreola* and *Argiallagma minutum* among the Zygoptera and *Idiataphe cubensis* among the Anisoptera. A decided case of localization was observed in the Guajataca River near Lares about 1,000 feet above sea level. Here were collected nymphs of *Dythemis rufinervis* and *Scapanea frontalis* in large numbers. A distance of two feet determined the species to be obtained. In a small pool, with its bottom covered with fine sand and

[1] See note at end. (page 85.)

silt, were to be collected the nymphs of the first. So numerous were they that they could be seen through the clear water, running in front of the net. Two feet below in the small riffles and clinging to the loose stones and pebbles of the gravelly bottom one could obtain only the nymphs of Scapanea.

It is a very striking fact the absence of the larger forms of Anisoptera like *Anax*, *Coryphaeschna* and others when compared with the smaller forms of the same suborder normally flying as adults all over the Island. Among the Zygoptera it is also noticed the relative absence of the *Lestes* spp., the largest Zygoptera on the Island, when compared with the rest of the members of this suborder. Wilson (1911) noticed also this fact while collecting in Jamaica. The factor determining this condition is not clearly understood, more so in the case of *Anax junius*. This species has been found in the nymphal stage in pools and in Tortuguero Lake where due to its large size it could have easily lived in competition with smaller forms. Yet the number of adults when compared with the rest of the forms in the mentioned lake was exceedingly low. A similar situation exists with *Coryphaeschna:* lots of nymphs were collected by Doctor Needham and the author in Tortuguero Lake, but not a single adult was seen. It could be thought that the season for transforming had not been reached, but in no case of the many occasions the author has been on the mentioned lake, has he seen the large anisopterans showing up. Possibly the large size of the nymphs make them easy pray to other more aggresive enemies or to some parasites, or either the adults have scludd habits and keep among the plants and trees close to the breeding places.

The geographical distribution of the odonate fauna of the West Indies, and thereby of Puerto Rico, has been discussed by de Selys (1856) who in placing the odonata fauna of Cuba at that time considered it closest to that of Florida and South America. He pointed out the scarcity of the Gomphinae, only represented by *Aphylla caraiba*, as well as the Calopteryginae represented only by another single species *Hetaerina luteola* Rambur (*Hetaerina cruentata* Selys) and the complete absence of the Cordulinae. Kolbe (1888) and Wilson (1911) considered affinities mainly with South American forms and Klots (1932) states " . . . that our characteristic Antillean fauna is most nearly allied to that of Central America, and that it arrived probably at the time of the late Tertiary connection with Central America, when all our present families of Odonata were in existence. . ." In accounting for a few forms found in Jamaica and Haiti and not present on the other islands she admits the

possibility of a ". . . secondary land bridge via the east-west mountain chain from Haiti through Jamaica to Honduras, in addition to the Yucatan–Cuba connection". She further indicates the importance of the flight habits of the dragonflies as well as the presence or absence of bodies of water and the latter in determining the distribution of this form of insect life.

In playing their part in the economy of nature odonates follow all other forms of animal life. Among the most common enemies of odonates are the birds which attack both nymphs and adults. Gundlach (1878) mentions 31 species feeding on insects, but in no case makes specific reference to particular insects and so no mention of the odonates is made. Bowdish (1902) (1903) mentions 30 species attacking insects, but only two of them *Mimus polyglottos orpheus* (Linnaeus), Jamaican Mocking bird, and *Melanerpes portoricensis* (Daudin), Porto Rican Woodpecker, are reported as having eaten adult dragonflies. Wetmore (1916) of 69 species feeding on insects mentions 12, or 17.4 per cent of them preying on odonates whether in adult or nymphal stage, (Table III), *Butorides virescens cubanus* (Oberholser), Cuban Green Heron, and *Marila affinia* (Eyton), Lesser scaup duck, heading the list in percentages. Eighty-four per cent of the stomach food contents of three herons was made up of the ". . . abdomen of adult dragonfly, nymphs and several damsel flies". and 69 per cent of the ducks food was made up of dragonfly nymphs. Danforth (1926) who discusses the stomach food contents of 53 species, (Table III), found 15 of these, or 28.3 per cent had eaten odonates. *Totanus melanoleucus* (Gmelin), Greater yellow legs, and *Falco columbarius columbarius* (Linnaeus), Pigeon Hawk, represent the two worst enemies of dragon and damsel fly nymphs respectively with corresponding percentages of 65.33 and 12 of their food. The Pigeon Hawk, again and *Egretta candidissima candidissima* (Gmelin), Snowy Egret, are the ones with heaviest toll among the adult dragon and damsel flies in the order mentioned with 73 per cent and 15 per cent respectively. Most of the adult odonates, may have been taken while transforming and not able to fly very much, but there is no doubt that some of them are caught while on the wing as has been observed by Danforth in the cases of *Hydrochelidon nigra surinamensis* (Gmelin), Blacktern, and *Tyrannus dominicensis dominicensis* (Gmelin), Gray kingbird, the latter seen catching *Lepthemis vesiculosa* (Fabricius) which is a rather swift dragonfly. Dr. James G. Needham has seen also this last bird catch on the wing *Tramea abdominalis* Rambur which in its flight is still faster than the former dragonfly.

In the nymphal stage dragonflies are picked upon more often than damselflies, a thing which is natural due to the small size of the damsel fly nymphs and also to their habit of clinging to small stems under water. Danforth's work shows that 53.3 per cent of the species of birds feeding on odonates attacked the nymphs of the dragonflies while only 13.3 per cent of them had eaten damselfly nymphs. In the adults the conditions are reversed, 40 per cent of the birds feeding on damselflies while 20 per cent feed on dragonflies. This is a good correlation, the latter being better fliers and standing usually in open spaces where they can see their enemies while the former are poor fliers, if compared with their relatives, and keep more often among the grasses close to the water on which they rest for longer periods and can be caught thus more easily.

Lizards have been reported to prey also on odonates, but Wolcott (1924) found only one case in 50 individuals of *Anolis pulchellus* Dumeril and Bibron, where a damsel fly, *Enallagma* sp., had been eaten. Dexter (1932) found that the nymphs of odonates constituted 0.8 per cent by bulk of the food of 301 specimens of *Bufo marinus* L. I have seen the latter sitting on the leaves of water plants from which I have collected transforming damselflies in Cartagena lagoon and certainly some of these have been eaten. Fishes are by far the worst enemies of the nymphs and in a few cases of adults. I have not found any data regarding Puerto Rican fishes.

But to all this fight with other species has to be added the struggle among the nymphs and adults of the odonates themselves. I have seen the big *Anax* feed upon the rapid *Lepthemis* and this in turn on *Erythrodiplax umbrata*, and Doctor Needham observed repeatedly cases of cannibalism among *Ischnura ramburii*. The fight easily seen in the air is no less intense and fierce in the water where the young nymphs fall easy prey to the larger ones.

The odonates in their adult stage are beneficial because of their predatory habits and destruction of many harmful insects like the mosquitoes. Nymphs may be counted also in the same category, but this is lessened by the fact that the nymphs may destroy young fishes. The adults feed upon mostly any kind of insect that they can get hold of. In Tortuguero Lagoon the numerous *Lepthemis* flitting in the air at the time of observation, February and March, were attacking the small white swamp moths *Nymphula fluctuosalis* Zeller which were then very abundant. These moths flew very low over the water surface, among the emergent aquatics, and so were in part protected from *Lepthemis*, but did not have such protection when attacked by *Lestes* sp. and other damselflies, which were feeding upon

them eagerly, because these latter ones fly also close to the surface of the water. In the Yúnez River in the gorge above the bridge on Km. 19.6, I have seen the big *Anax* together with some swallows, early in the morning, flying up and down the river and feeding on the adult mayflies dancing in the air about 30 to 40 feet above.

After the general remarks before made the following discussion will include observations applying to the individual cases and which could not be included before. The species will be placed for convenience in alphabetical order.

Aeschnidae

This family is represented by the subfamily Aeschninae only. The six species reported from the Island are by no means common either in the adult or nymphal stage. The most common one seen in flight is *Anax junius* and only a few recent records of *Aeschna cornigera* (A.M.N.H.) and *Coryphaeschna adnexa* (Needham and García-Díaz) are to be found. I saw once, at dusk, flying above the level of the electric light post about 30 feet high in Stop 38½ Hato Rey, near Río Piedras, an adult Gynacantha.[1] I have the impression of having collected also a teneral specimen of the latter under the wireless towers at Cayey, but the misplacing of the specimen makes it impossible to state it as a fact. The nymphs of *Anax* are by far the commonest and they are easily told from those of *Coryphaeschna*, when alive, because the latter have whitish eyes while the former do not.

Acanthagyna nervosa Rambur

No adults have been collected.[1] Gundlach (1888), collected them in Cuba on December 15 near Cárdenas and in the Zapata swamp; Kohl (1916) records them from the Isle of Pines, September 11, 1912. The nymph, if Klots' (1932) supposition is right, was caught July 31st, 1926, on the university campus in a ditch with temporary water where the sewage overflow of a building was discharged. The water was ill-smelling due to a dead cat in the water a short distance from where the nymph was collected. No other odonate nymphs were found here and only some tadpoles with it. From this it appears that the nymph does not require clear running or clean water. The tadpoles probably served as food.

Aeschna cornigera (Brauer)

The adult upon which this record rests was caught in Adjuntas, June 8–13 (A.M.N.H.). No other adults have been seen or collected.

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[1] See note at end. (page 85.)

A nymph collected by Doctor Needham, March 23, 1936, in a creek ic front of Camp Buena Vista in the Maricao Forests, over 2,350 feet above sea level, seems to be an Aeschna, but is too young to make an accurate determination.

Anax amazili (Burmeister)

(Pl. VI, Fig. 8)

No adults have been collected in Puerto Rico. The record rests on two nymphs collected by me in Hato Rey, Stop 30, near Río Piedras, September 15, 1926, and determined as such by Byers (1927). The nymphs were full grown. The place where they were collected was a rather shallow temporary pool, not over three feet deep at its most, whose water remained usually very clear during the rainy season. Many other odonates as nymphs and adults were collected and seen in this pool, but only *Anax junius* belonging to the Aeschninae was caught here on different occasions on the wing. The pool dried up completely during the year so the life cycle must take place in a year or less. This is possible if we take into consideration Calvert's (1934) paper, who although he thinks that in the greater part of North America two successive generations of *A. junius* do not occur, admits "that under continued high temperature of both water and air two generations per year may be possible". The last two mentioned climatic conditions are easily met on the Island. No more nymphs have been collected. The place of original collection is no longer in existence since the hollow was filled up.

Hagen (1867), calls this species from Cuba "scarce". Calvert (1899) has a record of a female from Tepic, October 1894, 1036 meters altitude, and from Cuba Gundlach (1888) gives records November 15, 1888 and adds "un ejemplar fué cogido en Octubre 1871 en la Habana". This shows the species occurs at widely different altitudes and its indicated infrequent occurrence in Cuba possibly accounts for absence of adults in Puerto Rican collections.

Anax junius (Drury)

Although not very often seen, the records show it is to be found throughout the entire year and from sea level 2,000 feet up. Most easily caught when copulating because when doing so the pair usually rests along the shore of the pond. Needham (1901) has discussed the habits of the nymphs which are "notoriously cannibalistic" a fact possibly acounting for the very few reaching adult stage. La Muda, Feb. 21; Almirante Road Km. 6.7, March 9; Lares, March 22;

Cabo Rojo, Feb. 23; Needham and García-Díaz. Nymphs; Lake Tortuguero, Feb. 19; March 20; Almirante Road, Km. 6.7 March 18, Needham and García-Díaz; Cartagena Lagoon, Oct. 31; Isabela, May 12, García-Díaz.

Coryphaeschna adnexa (Hagen)

(Pl. V, Fig. 4; Pl. VI, Fig. 7)

In only two places were adults of this species seen. I have records from Cuba in May, June and November which tends to show that adults occur throughout the whole year if these records are added to the ones indicated here.

Large numbers of the nymphs of this genus were collected on the west end of Lake Tortuguero among *Polygonum* plants in standing water about 2½ feet deep. The nymphs of *Anax* were equally numerous. The white eyes of *Coryphaeschna* distinguish them at once.

Florida Road, Km. 4.6, Feb. 28; La Muda, Feb. 21; Needham and García-Díaz. Nymphs: Tortuguero Lake, March 20; Needham and García-Díaz; Isabela, May 12; Cartagena Lagoon; Oct. 31; García-Díaz.

Gynacantha trifida (Rambur)

Not a single record has been added to those of Stahl, Kolbe and Gundlach.[1] A nymph considered by Klots as Acanthagyna has been reported from the Island. I think I have seen and collected this species as stated before. Their habit of flying at dusk is possibly responsible for their absence in collections and Gundlach's mention of their occurrence in the woods is another possibility. It has been caught in Cuba during August and September, occurring in large flocks along the coast and seen migrating from north to south in December.

LIBELLULIDAE

These are the dragonflies most often seen and collected all over the Island. Some of the species ar remarkable for their absence in collections. Among these are *Micrathyria didyma didyma* and *Micrathyria hageni,* specimens of which have not been collected after Gundlach's and Kolbe's records. Two more genera have recently been added to the Puerto Ricant list, *Idiataphe* (= *Ephidatia*) *cubensis* and *Brachymesia furcata.* *Tramea onusta* and *Micrathyria*

[1] See note at end. (page 85.)

aequalis are also new records for the Island. Only where field notes are at hand or additional records to those of Klots (1932) will be discussed below.

Bachymesia furcata (Hagen)

(Pl. VI, Figs. 1, 3, 5)

One of the new records. A single adult male caught in flight in Coamo Springs near the reservoir April 5, 1930, Needham and García-Díaz. No more adult specimens have been collected on the Island, but no collecting has been done in the place of collection since the data before mentioned.

Cannacria herbida (Gundlach)

(Pl. VI, Figs 2, 4, 6; Pl. VI, Fig. 1)

This species seems to be restricted to the costal plain where adults are quite common throughout the year. The adults fly close to the water and to the edge of the river, pond or lake. Usually they select a stick over the surface of the water where they perch persistently and to which they return after repeated disturbance. A female was seen ovipositing in the Bayamón River close to the sea where the water becomes more or less brackish when the nearby sea sweeps in. While ovipositing, unattended by male, she descended swiftly, at long intervals, to the water surface dipping the tip of her abdomen. This procedure certianly made eggs less liable to the fish havoc. No nymphs were discovered at this time. On August 10th the nymphs assumed to be this species by comparison with those of *Cannacria gravida* as discussed by Needham and Fisher (1936) and with Doctor Geijskes' description (1934) were exceedingly common along the Cartagena Lagoon shore.

Tortuguero, Feb. 10, Needham and García-Díaz; Tortuguero, Feb. 15; Río Piedras, Feb. 12; Palo Seco, Mar. 21, Needham and García-Díaz; Río Piedras, Flying to lights at home, one female, May 19; Lago Las Torres, June 21; Cartagena Lagoon, August 10, October 31; Yauco, November 11; Fajardo, Las Cabezas, December 19, García-Díaz. Nymphs: Cartagena Lagoon, August 10, García-Díaz.

Dythemis rufinervis (Burmeister)

This is a species which could be placed with the lotic ones, but is capable of living under completely static environment since it is found high up in the mountain rivers, 2,000 feet, and also in Tortuguero Lake at sea level. The adults are twig perchers. Once

they select a place to stand they come back to it repeatedly when disturbed and even after being hit by the net. The males fly close to the water edge over the stream. They are alert, fast flyers and difficult to get when in flight. The nymphs were collected in large numbers in the Guajataca River, in running water, but in a shallow pool with sandy bottom upon which the nymphs rested. They were not easily seen when at rest, matching with the surroundings, but once moving one could easily see them as they moved on the sand or swam through the water in front of the sieve net. They are capable of standing dryness since some placed in a pail in the late afternoon got out of it and were found next morning in the car or crawling over the sidewalk close to which the car had been left.

Tortuguero Lake, Feb. 10, Needham; La Muda, Feb. 21; Cartagena Lagoon, Feb. 23; Tortuguero Lake, Feb. 15; Florida Road Km. 19.3; Yúnez River, Feb. 28; Río Blanco, Power plant, March 8; Almirante Road, Km. 6.7, March 3; Arecibo, Tanamá River, March 13; Lares, Guajataca River, March 23; Cabo Rojo, Feb. 24, Needham and García-Díaz; Ponce, Río Bucaná, June 21, Coamo, Río Puyón, June 20, García-Díaz. Nymphs: Lares, Guajataca River, March 23; Caguas, March 4; Florida, Yúnez River, Feb. 28; Río Piedras, March 18, Needham and García-Díaz; Florida, Yúnez River, Aug. 14, García-Díaz.

Erythemis plebeja (Burmeister)

One of the most difficult dragonflies to obtain because of its alertness and swift flight and also because it usually chooses open spaces for perching where it is difficult to catch. Cabo Rojo, Feb. 23; Florida, Yúnez River, Feb. 28; Lake Tortuguero, March 20, Needham and García-Díaz; Lago Las Torres, June 21; Cartagena Lagoon, October 31, García-Díaz.

Erythrodiplax connata justiniana Selys

I have found them most abundant in swampy places usually with a lot of vegetation but they occur also along the rivers. They are fast fliers and their direction in flight is erratic. They fly low and seldom stand on the higher plants, preferring the lower ones, usually selecting new perching places every time. Once having located a place where they occur, one is sure to get a good series since they keep close to the place even if many times disturbed. On March 13, 1935, on Almirante Road and in a swamp about one hundred yards west from the road sign Km. 6.7, I collected a good series of this

species many of which had recently emerged. I failed to obtain nymphs since I did not search for them. Two years before, June 27, 1933, I got also a very good series on this locality by the road side. Doctor Needham has a nymph caught in Florida Road Km. 4.6, which he thinks is this species. The adults, though sometimes localized, have been found widely spread over the Island reaching altitudes of 2,000 feet. They like *E. umbrata* do not prefer the open spaces, but the grasses and bushes back of the open waters.

Yúnez River, on the Florida Road Km. 19.3, Feb. 28; Almirante Road Km. 6.7, March 9, 13; Lake Tortuguero March 19–20, Needham and García–Díaz; Almirante Road, Km. 6.7, June 27; Coamo, Río Puyón, June 20, Lago Las Torres, June 21, García-Díaz.

Erythrodiplax minuscula (Rambur)

Judging from collecting done at different times on different places over the Island, this species, like E. *berenice naeva,* is not common. Cartagena Lagoon, October 31, García-Díaz.

Erythrodiplax umbrata (Linnaeus)

Usually the most comon species of dragonfly on the Island. It prefers, as said before, places back of the open water among the weeds or bushes. Not very hard to catch. When flying over the water they keep close to the surface. Copulate most of the time without coming to rest in a very short time and the female begins ovipositing at once, dipping the tip of the abdomen at different places in a small area and then moving to some other place. A striking fact is that although adults are common, the nymphs are not so commonly and easily collected. Possibly the nymphs have habits similar to those of *Idiataphe.*

Idiataphe (= *Ephidatia*) *cubensis* (Hagen)

(Pl. VII, Fig. 3)

Cowley, (1934) finding *Ephidatia* preoccupied has proposed *Idiataphe* for this genus. Dr. James G. Needham found this species for the first time February 10, in Tortuguero Lake where he reared it and has published the description of the nymph. Needham and Fisher (1936). Puerto Rico is the second place in the West Indies where this species has been found. A curious happening is that in Tortuguero Lake, on two different instances—March and August,—the cast skins were numerous, clinging to the stems of sedges and

grasses as well as on the leaves of the same, but the adults were exceedingly scarce to the extent that only two or three were obtained. Do adults keep in secluded places or are they destroyed by some enemies? If the adults are peculiar about their habits no less are the nymphs. For nearly a whole forenoon were nymphs searched for with the sieve and apron nets along the shore of the lake among weeds and water plants with no success. Doctor Needham's suggestion of the possiilbity of hiding among the roots made possible collecting a few living ones. Upon pulling some sedges growing in the water or close to the water edge, they were found living there. Among the roots of some stumps of *Chrysobalanus Icaco* L. in the water along the shore, they were found also. Finding them is a real job and only five nymphs were obtained. Although this species seems to be strongly localized as shown by the record of having been found only in Tortuguero Lake, not too much stress can be placed upon this fact when the habits of nymphs and adults are taken into consideration.

Lake Tortuguero, Feb. 10, Needham; Lake Tortuguero, March 20, Needham and García-Díaz. Nymphs: Lake Tortuguero, Feb. 10, Needham; Lake Tortuguero, Feb. 14, Needham and García-Díaz.

Lepthemis vesiculosa (Fabricius)

One of the most common, if not the comonest, species on the Island. Adults fly tirelessly along the open waters, keeping most of the time close to the shore. They may be ecxeedingly common and yet few cast skins may be found. When copulating they come to rest, those that I have seen, and are then easily caught as in *Anax*. Though I have seen large numbers of them, I have not noticed many of them copulating. The female when ovipositing keeps close to the water and dips her abdomen in the water in limited areas and then moves on. When the tip of the abdomen of an ovispositing female is placed in a vial, the eggs are seen to come out singly, but rapidly, in a stringlike fashion. They stick easily to the bottom or sides of the vial, are whitish-yellow in color, but on standing turn brown. The nymphs live in pools and standing waters, but also in running water since in 1930 Doctor Needham collected numerous nymphs among algae mats growing in the shallow Coamo River back of Coamo Spring hotel. The highest altitude record is 1,800 feet. On Fig. 1 there are some months in which *Lepthemis* is not recorded. This is because there are no actual records, but there is no doubt that this species occurs throughout the entire year.

Macrothemis celeno (Selys)

A widely spread species over the Island. Primarily a lotic one, ranging from sea level to above 2,000 feet. The adults fly along the rivers and usually come to rest on the gravel or stones along the edges. They are very difficult to catch because of their swift flight. When standing on the stones or gravel one has to strike from above, since they have the habit of shooting straight up from their resting place if disturbed. A female seen ovipositing unattended by the male, flew eight to twelve inches above a sandy riffle and made lightning-quick dashes to the water's surface and back again to the same level, hitting the water lightly with the tip of the abdomen each time, this descent and return made so quickly that the eyes could hardly follow. Although present in lower levels, it is most common and easily seen along the water courses in the high levels. The nymphs in the rivers are found among the overhanging roots and stems of plants growing close to the edges.

La Muda, Feb. 21; Florida, Yúnez River, Feb. 28; Río Blanco, on Hicaco River dam above the power plant, March 8; Lares, Guajataca River, March 22; Arecibo, March 13, Needham and García-Díaz, La Catalina, Luquillo Mts., JulJy 2; Ponce, Río Bucaná, June 21; Coamo, Río Puyón, June 21; Cartagena Lagoon, October 31; García-Díaz. Nymphs: La Muda, Feb. 9, Florida, Yúnez River, February 28, Needham and García-Díaz.

Miathyria marcella (Selys)

Apparently restricted to the costal plain where it has been only collected up to the present time.

Cartagena Lagoon, Feb. 23, Needham and García-Díaz; Cartagena Lagoon, October 31, García-Díaz. Nymph: Río Piedras, Forestry Department pool, Feb. 7, Needham.

Micrathyria aequalis Hagen

Collected only north of Cabo Rojo along an irrigation ditch. Not reported before from the Island. Very similar to *M. dissocians* but easily distinguished because of its smaller size and the smaller white spots on segment 7. Cabo Rojo, Feb. 24, Needham and García-Díaz.

Micrathyria dissocians Calvert

The most common species of the genus occurring on the Island in sharp contrast with the marked absence of *M. didyma didyma* and

M. hageni which rest yet upon Gundlach's and Kolbe's records. Apparently confined to the costal plain.

Isabela, March 25, Needham; Cabo Rojo, Feb. 24; Florida, Yúnez River, Feb. 28; Almirante Road Km. 6.7, near Vega Baja, March 9, Arecibo, March 13, Needham and García-Díaz; Almirante Road, Km. 6.7 near Vega Baja, June 27, García-Díaz.

Orthemis ferruginea (Fabricius)

The collecting records thus far are from eastern two-thirds of the Island, but it is certainly present all over. It has been caught from sea level up to the 2,000 feet line. There is no doubt that it will be found above this since this species is capable of wide vertical distribution. A species rather difficult to catch because of its swift flight and perching on twigs in open spaces. Some adults are remarkably red. I have seen a female ovipositing on the tiles of the vestibule of a building in the University and when disturbed insisted upon coming back and doing it again. An adult was caught also April 12, flying to the lights at my home. The nymphs of two reared adults when compared with Klots' (1932) supposition for *Brachymesia gravida* confirmed Doctor Needham's (1936) belief that such supposed nymph is but an *Orthemis*.

Florida, Yúnez River, Feb. 28; Río Blanco, by power house, March 8; Almirante Road Km. 6.7 March 9; Lake Tortuguero, March 20, 21; Arecibo River, March 13, Needham and García-Díaz. Río Piedras, an adult flying to home lights, April 12; La Catalina, Luquillo Mts., July 22; Ceiba, Ensenada Honda, July 24; Río Piedras, June 22; Fajardo, Las Cabezas, December 19; Yauco, November 1; Ponce, Río Bucaná, June 21, García-Díaz. Nymphs: Isabela, March 25, Needham.

Pantala flavescens (Fabricius)

Not so common as the other species. Prefers sunny open spaces where it flies tirelessly keeping usually almost the same level, and about five feet from the ground, while getting its food. Usually there are a few together when doing so.

Lake Tortuguero, Feb. 10, Needham; Almirante Road, near Vega Baja, Km. 6.7, March 9, Needham and García Díaz; Fajardo, Quebrada Vuelta, July 24; Yauco, Dec. 1, García-Díaz.

Perithemis domitia (Drury)

The adults are not commonly seen, recorded only from three places on the Island, probably due to their sensitiveness, as mentioned by

Needham and Haywood (1929) to bright shiny or cloudy damp days. I collected a good series of nymphs in a sink hole pool near Isabela, Road No. 2 Km. 103 on May 12. The pool was extremely muddy, heavily loaded with organic matter made up mainly of leaves which had fallen from the trees which surrounded and partially covered the pool. The water fleas and small ostracods were so common that they formed brown patches on the surface and around any stumps above the surface of the water. The nymphs were found along the edges of the pool. Some of them were taken to the laboratory and reared, yielding seven females and three males. The former agree with Dr. Ris (1930) remarks about specimens from Cuba as quoted by Klots (1932). Five of the females show also a brown spot on the anterior wing occupying the first cell of the bridge and part of the cells under this as well as the first cell between M_1 and M_2 sometimes extnding to the other cells above and below this latter ones. On the posterior wing a similar spot past and close to the oblique vein filling part of the area of the cell as well as some of the cells above and below. In two females the spots did not show clearly, but the faintly colored areas could be partially made out. Perhaps the specimens were killed before coloring up completely. The large number of females to males in the lot reared, though it may have no meaning at all, is in strong contrast with their absence in collected specimens. A female seen ovipositing, unattended, in the above-mentioned pool flew close to a piece of wood emerging above the surface of the water and while in flight rapidly and repeatedly touched the wood close to the surface of the water; she did this for a number of times, quit, and began doing it again, repeating the process on different occasions.

Cabo Rojo, February 24, Needham and García-Díaz; Isabela, May 12, García-Díaz, Nymph: Isabela, May 12, García-Díaz.

Scapanea frontalis (Burmeister)

This is mainly a lotic species on the Island and restricted principally to the higher levels, although there are records from Mayagüez and Wilson (1911) found it also in Jamaica "along the dead water at sea level". But the nymphs in Puerto Rico have been collected, up to the present, only above the 500 feet level, becoming commoner higher up. The living adult males make themselves conspicuous while in flight by the white spot near the tip of the abdomen segments 7, 8, and 9, and which does not show in many preserved specimens. The females do not show this spot. Both are strong

fliers flitting close to the water up and down the course of the stream, loitering over pools. They are stremely shy, though approachable, but of one is missed by the net usually all go away. Most of them are caught on the wing. They copulate without coming to rest. Their nymphs are capable of standing dryness to a large degree since they crawled out of a bucket of water during the night, and like those of Dythemis mentioned before, were found the following day on the floor of the car and on the sidewalk. They prefer rapid running water, clinging to the stones—some of them to the under surface.

Luquillo Mountains, February 18; Río Blanco, above Hicaco River dam, March 8; Lares, March 22, Needham and García-Díaz. Nymphs: Florida, Yúnez River, Feb. 28; Arecibo River, near Utuado, March 13; Lares, March 13; Needham and García-Díaz.

Tramea abdominalis (Rambur)

The most common of the Trameas on the Island. Besides flying alone I have seen them flocking together in large numbers while feeding on the Chironomids which keep in cluster from 12 to 15 or 20 feet above the ground. The female may oviposit unattended or with the male. When the latter happens the male releases the female from one to two inches above the surface of the water, when she descends to oviposit hovering meanwhile above and on her coming up the male seizes her again; both fly for a short time and repeat the action described. If the female is missed by the male she continues to oviposit unattended, sometimes the male trying to get hold of her repeatedly. The eggs, yellowish in color, descend slowly in a cluster of 7–10 eggs to the bottom. The keeping of the eggs together in such a fashion without scattering, renders them no doubt subject to the attacks of fishes and other enemies and here is a possible explanation of the comparative scarcity of nymphs of this genus when compared with the number collected of nymphs of other genera.

Río Piedras, Feb. 7, 9; Tortuguero Lake, Feb. 10; Isabela, March 25; Needham; Tortuguero Lake, Feb. 15; Cartagena Lagoon, Feb. 23; Cabo Rojo, Feb. 24; Florida, Yúnez River, Feb. 28; Río Blanco, near power house, March 8; Almirante Road Km. 6.7; March 9; Arecibo, March 13, Tortuguero Lake, March 20, 21, Needham and García-Díaz; Almirante Road, Km. 6.7, June 27; Cartagena Lagoon, Oct. 31; Lares, Oct. 30; Peñuelas, March 24; Lago Las Torres, June 21, García-Díaz. Nymphs: Cartagena Lagoon, Feb. 23, (reared), Neeham and García-Díaz.

Tramea binotata (Rambur)

The least common species of *Tramea* found on the Island if compared with the other two. The nymph is unknown. Florida, Yúnez River, Feb. 28; Almirante Road, Km. 6.7 near Vega Baja, March 9; Arecibo, March 13; Tortuguero Lake, March 19, 20, Needham and García-Díaz.

Tramea onusta (Hagen)

A species not reported from the Island although from the West Indies. I have collected them flying together and among the flocks of *T. abdominalis*. Not captured at higher levels but undoubtedly there.

Cartagena Lagoon, Feb. 23; Arecibo River, March 13; Tortuguero Lake, March 20, 21, Needham and García-Díaz; Ceiba, July 24; Fajardo, Las Cabezas, December 19; Yauco, Nov. 1, García-Díaz.

ZYGOPTERA

An additional genus, *Argiallagma* has to be added to those already listed from the Island and also a species, *Enallagma cultellatum*. Small as are some of them an with peculiar habits of life, as will be indicated presently under each species, a few of these odonates are liable to be overlooked. The status of their nymphal stages remains practically the same as stated by Klots (1932) with the only exceptions of *Enallagma coecum* and *E. cultellatum*, both of which have been reared. To these two should be added a supposition believed to be the nymph of *Argiallagma*. These three nymphs with others of the Anisoptera are discussed further on. It is a striking fact that the nymphs of these odonates, with the exception of those of *Ischnura* and *Enallagma coecum*, are very uncommon although the adults occur in the place where collecting is done. A single family *Coenagrionidae* with two subfamilies *Lestinae* and *Coenagrioninae* have been thus far reported.

Anomalagrion hastatum (Say)

The most inconspicuous of all the zygopterans on the Island and easily overlooked because, although the male has a yellow color, this blends with the dry leaves of the plants in the nearly dry places back of the open waters where they occur. They keep among the plant and weeds and the females, mostly dull colored, are also not easily seen. It seems to be restricted to the lower levels reaching the 500 feet line where it has been collected, though future collecting may alter this view.

Río Piedras, Forestry Department pool, Feb. 8, 9; Tortuguero Lake, Feb. 10, 15, Needham; Guánica Lagoon, Feb. 24; Río Piedras River back of Experimental Station, Feb. 12; Florida, Yúñez River, Feb. 28; Almirante Road, Km. 6.7; near Vega Baja, March 9; Tortuguero Lake, March 19, 20, Needham and García-Díaz; Almirante Road, Km. 6.7, June 27, García-Díaz.

Argiallagma minutum (Selys)

(Pl. IV; Pl. V, Figs. 1, 3; Pl. VII, Fig. 2)

Doctor Needham collected this species for the first time on the Island in Tortuguero Lake, Feb. 10, and later at Almirante Road, Km. 6.7, March 9. Regarding the collecting at this last place he says: ". . . the *Argiallagmas* were captured among the weeds, none over the pond, but in plashy places where they could flit through the small intervening openings from stem to stem. I broke paths through the weeds so as to get about more easily, and then traversed these, scanning the bordering stems for the delicate little damselflies. They did not seem to be common but by diligence got a good lot. Only rarely was any other species found near them; *Anomalagrion hastatum* betimes and very rarely an *Ischnura ramburii;* this latter lives more openly."

So far this species has been collected from only two places and no comment can be made as to its distribution considering the above notes, but it seems to be a localized form. In August I went to Almirante Road, where Doctor Needham had collected adults, to obtain some nymphs, but was unable to find them. Although I searched most carefully, I saw but one adult specimen which I missed when I tried to capture it. I collected though some in Tortuguero Lake.

Tortuguero Lake, Feb. 15, Needham; Almirante Road, Km. 6.7; near Vega Baja, March 9 in copula; Tortuguero Lake, March 20, (in copula), Needham and García-Díaz; Tortuguero Lake, August 16, (in copula), García-Díaz. Nymph: (Supposition) Almirante Road, Km. 6.7, March 9, Needham and García-Díaz.

Ceratura capreola (Hagen)

(Pl. V, Figs. 2, 5)

Another species which tends to be a localized one, keeps among the plants and weeds not flying in the open. Nothing is known about its habits and the nymph is unknown, although Klots (1932) published a supposition and another is also discussed in this paper.

Tortuguero Lake, Feb. 15, Needham; Tortuguero Lake, March 20, Needham and García-Díaz; Florida, in swampy hollow close to River, Aug. 15, García-Díaz.

Enallagma civile (Hagen)

These dainty blue damselflies are found most often in pools and standing water; they may be found also along running water. In flight they keep close to the surface of the pool and do not fly for very long periods, pausing repeatedly on anything above the water or among the plants along the edge. They have been collected from sea level to 2,000 feet. Although adults are common the nymphs are apparently scarce for reasons given in the discussion of the nymphs farther on.

Río Piedras, Forestry Department pool, Feb. 8; Río Piedras, River back of the Experimental Station, Feb. 12; Isabela, March 25, Needham; Cartagena Lagoon, Feb. 23; Florida Road, Km. 4.7, Feb. 28; Almirante Road, Km. 6.7, March 9; Tortuguero Lake, March 20, Needham and García-Díaz; San Germán, April 28; Almirante Road, June 27; Cartagena Lagoon, August 9, 10, November 31, García-Díaz.

Enallagma coecum (Hagen)

This species is primarily lotic, preferring running water but it may be found also along standing waters. Widely distributed over the Island. Its nymph has been collected above 1,000 feet level and the adults above the 2,000 feet line. The former have the habit of hiding among the roots of sedges growing close to the water near the edges and are found also among overhanging roots of other plants. In a random collecting in the creek at Florida Road, Km. 4.7, the nymphs of this species outnumbered those of Ischnura in a ratio of ten to one. No other species of Zygoptera were found with them.

La Muda, Feb. 9; Río Piedras, River back of the Experimental Station, Feb. 12; Florida, Yúnez River, Feb. 28; Florida Road, Km. 4.7, Feb. 28; Caguas, Cagüitas River, March 4, Río Blanco, above Río Hicaco dam, March 8; Almirante Road Km. 6.7, March 9; Tortuguero Lake, March 20; Adjuntas, March 23; Arecibo, Tanamá River, March 13; Needham and García-Díaz; Cayey Wireless Station, May 6; Florida, Yúnez River, August 15; La Catalina, Luquillo Mountains, July 22; San Germán, River near the town, April 28; Ponce, Río Bucaná, June 21; Coamo, River Puyón, June 21, García-Díaz. Nymphs: Florida, Yúnez River, Feb. 28; Florida Road, Km. 4.7, Feb. 28; Caguas, Cagüitas River, March 4; Río

Blanco, above Hicaco River dam, March 7; Almirante Road, Km. 6.7, March 9; Arecibo–Utuado Road, Kms. 56 and 60 near Utuado, March 13; Río Piedras, March 18; Lares, Guajataca River, March 22; Adjuntas, March 23, Needham and García-Díaz; Florida, Yúnez River, June 21; in marshy-swampy hollow close to River, August 15, García-Díaz.

Enallagma cultellatum (Hagen)

(Pl. V, Fig. 6, 7)

Found only in Tortuguero Lake by Doctor Needham, February 10, thus adding another species record for the Island to the genus. On February 15 there were many in copula and some of them ovipositing. A female while carrying this latter process stood on a leaf of *Nymphoides humboldtianum* bending its abdomen around the margin and under the leaf on whose lower epidermis made crescent shaped slits and stuck the eggs with their micropylar end pointing towards the openings of the slits. These were placed in a semicircular arrangement. The eggs had a black conic apex surrounded by some substance which was impossible to ascertain whether it was a secretion or part of the epidermis of the leaf. While the female was ovipositing, the male kept hold on her, standing out in the air. Some nymphs were transforming and specimens were collected on the stems of plants about a foot above the water. These can be easily told from the other species by the rather stout, highly chitinized, terminal spine at the end of the serrated edges of the gill plates. Some of the adults were seen standing along the sandy shore of the lake and were common. This was in contrast with conditions in August when I saw very few, being able to collect but an adult and an additional teneral one. Possibly another localized species, the male is easily distinguished by its bright yellow frons, clypeus and labrum. A young nymph from Caño Tiburones places it among the hardiest ones for reasons given under the next species.

Tortuguero Lake, Feb. 10, Needham; Feb. 15, Needham and García-Díaz; August 16, García-Díaz. Nymphs: Tortuguero Lake, Feb. 10, (cast skins) Needham; Feb. 15; Caño Tiburones, March 12, Needham and García-Díaz.

Ischnura ramburii (Selys)

The most common damselfly on the Island through the entire year, but apparently restricted to the lower levels. There are no records above the 300 feet line. They become so numerous at times that failing to find food enough for all, they resort to cannibalism.

The pairs in copula fly for long periods together, resting among plants and flying about, but not necessarily ovipositing. This is another of the hardiest Zygopterans on the Island, since I collected nymphs in the waters of Caño Tiburones which are decidedly brackish because of their connection with the sea by way of the Arecibo River.

Río Piedras, pool in Forestry Department, Feb. 7, 8, 9; Tortuguero Lake, Feb. 10; Maunabo, Feb. 11; Isabela, March 25, Needham; Río Piedras, River back of Experimental Station, Feb. 12; Tortuguero Lake, Feb. 15; Cartagena Lagoon, Feb. 23; Guánica Lagoon, Feb. 24; Florida Road, Km. 4.7, Feb. 28; Caguas, March 4; Almirante Road, Km. 6.7, March 9; Arecibo, March 13; Lake Tortuguero, March 19, 20; Palo Seco, March 21, Needham and García-Díaz; Cartagena Lagoon, August 10, García-Díaz. Nymphs: Tortuguero Lake, Feb. 15; Río Piedras, River back of the Experimental Station, Feb. 18; Cartagena Lagoon, Feb. 23; Guánica Lagoon, Feb. 25; Caño Tiburones, March 12; Tortuguero Lake, March 20, Needham and García-Díaz; Isabela, May 12; Cartagena Lagoon, August 10, October 31, García-Díaz.

Lestes forficula (Rambur)

The most common species of the Lestinae, occurring mainly along the coast but nymphs of it have been collected at Las Cruces on Road number one in a place 1461 feet high. The females may oviposit attended or not by the male. In the first case the male clings to the support while the female thrusts her ovipositor into the tissues of the weed or water plant. A female was seen ovispositing in the leaves of a sedge from 8 to 10 inches above the surface of the water. Other times they oviposit closer to the surface and gradually go down the support below the surface inserting their eggs, until nearly the whole abdomen is in the water.

Río Piedras, pool in Forestry Department, Feb. 8; Tortuguero Lake, Feb. 10; Isabela, March 25, Needham; Río Piedras, River back of the Experimental Station, Feb. 12; Tortuguero Lake, Feb. 15; Cartagena Lagoon, Feb. 23; Florida, Feb. 28; Almirante Road, Km. 6.7, March 9; Arecibo, March 13; Tortuguero Lake, March 19–20, Needham and García-Díaz. Tortuguero Lake, August 17, García-Díaz. Nymphs: Río Piedras, pool in Forestry Department, (reared), Feb. 8, Needham; Tortuguero Lake, (reared), Feb. 15; Cartagena Lagoon, (cast skins only), Feb. 23, Needham and García-Díaz.

Lestes scalaris (Gundlach)

Not common, if compared with the preceding one, on the Island.

Florida, Yúnez River, Feb. 28; Almirante Road, Km. 6.7, March 9, Needham and García-Díaz.

Lestes spumarius (Selys)

The least common species of Lestes on the Island, judging from the records which are only those of Selys and an additional one of the American Museum of Natural History. No specimens were obtained even when looked for in the place last mentioned.

Protoneura capillaris (Rambur)

A single specimen of this species caught on the Island after Selys (1886) record; unluckily the date was not indicated, about 1928. Flying to lights.

Río Piedras, Hato Rey Stop 38½, García-Díaz.

Telebasis dominicanum (Selys)

This species, and the following one prefer to the open spaces the margin of the bodies of water where they are found or else among the weeds some distance from them. Adults have been collected from sea level to the 2,000 level.

Río Piedras, River back of the Experiment Station, Feb. 12; Guánica Lake, Feb. 24; Florida, Yúnez River, Feb. 28; Florida Road Km. 4.7; Caguas, Cagüitas River, March 4; Almirante Road, Km. 6.7, March 9; Arecibo, Tanamá River, March 13, Needham and García-Díaz; San Germán, River near town, April 28; Florida, swamp in hollow close to the river, August 15; Almiante Road, Km. 6.7, June 27, García-Díaz.

Telebasis vulnerata (Hagen)

(Pl. V, Figs. 8, 9)

The adults of these species have been collected in more places than the preceding one. Well distributed all over the Island with habits as indicated already. I have collected specimens above 2,000 feet level in the Luquillo Mountains in and above La Mina Recreational Area, flying in the shade along the courses of the small creeks.

No nymphs of these species have been described so far. A female specimen reared by Doctor Needham from Buena Vista Camp in Maricao is described farther on. Klots' nymph (1932) is that of *Enallagma coecum.*

TABLE 1

MEASUREMENTS OF CAST SKINS OF *B. furcata* and *C. herbida*

	Brachymesia furcata						*Cannacria herbida*						Averages		Geijskes' measure.
	I (a)	II	III	IV	V	VI	I (a)	II	III	IV,	V	VI	*furcata*	*herbida*	
Length of body	.....(b)	21.2	22.0	20.9	22.6	....	21.9	20.5	23.0	24.5	23.5	22.0	21.67	22.56	18.5–19.
Length of abdomen	14.0(c)	14.5	14.2	13.6	14 9	14.2	15.4	14.2	14.7	16.0	15.7	15.0	14.23	15.16	........(f)
Length of post-wing pad	6.75	6.75	6.75	6.75/7.05	7.2	6.75	6.75	6.45	6.6	6.6	6.67	6.6	6.82	6.61	6.5
Width of head	....	5.55	5.70	5.7	5.7	....	5.25	5.17	5.85	6.0	5.7	5.7	5.66	5.61	6.0
Width of abdomen	8.0	8.5	8.50	8.5	8.0	8.2	7.35	7.2	7.35	7.48	7.7	7.35	8.28	7.4	6.0
Labium:															
Length	....	3.3	3.30	3.3	3.3	....	3.82	3.75	4.2	4.27	4.27	4.12	3.3	4.07	....
Width	....	4.05	3.97	4.05	4.05	4.05	4.27	4.12	4.57	4.68	4.72	4.50	4.03	4.47	4.5–5.0
Lateral setae	....	8	8	7	7	8 / 7	8	8	9 / 10	10	10	10	7–8	8–10	10
Mental setae	....	10	10 / 13(e)	10 / 11	12 / 10	10 / 11	8 / 10	8	13	14 / 13	13	13	10–13	8–14	12–13
Setae on labial teeth	....	2.4	1–5	1–5	1–5	0–4	1–3	1–3	1–3	1–2	1–3	1–3	0.5	1–3	2–5
Abdominal appendages															
Superior	1.95	1.87	1.8	1.83	1.87	1.9	3.0	3.0	2.85	2.85	2.85	2.85	1.87	2.9	.92
Lateral	.937	1.05	.97	.937	1.05	.975	1.05	.975	.975	1.05	1.05	1.05	.986	1.02	.80
Inferior	1.95	1.87	1.87	1.87	1.95	1.95	3.0	3.0	2.85	2.85	2.85	2.85	1.91	2.9	.96
Dorsal hooks of abdomen (d)	3–9	3–9	3–9	3–9	3–9	3–9	3–9	3–9	3–9	3–9	3–9	3–9	3–9	3–9	3–9
Spine on 8th segment	.45	.45	.45	.45	.45	.45	.63	.75	.45	.73	.63	.63	.45	.636	.28
Spine on 9th segment	.75	.63	.67	.60	.60	.60	1.12	1.2	.70	.90	.90	.82	.64	.94	.80
Length of 10th segment	.45	.45	.45	.45	.52	.45	.52	.525	.45	.52	.48	.45	.46	.49	....
Length of femora:															
I	3.52	3.75	3.60	3.67	3.75	3.75	3.30	3.15	3.3	3.48	3.3	3.37	3.67	3.31	3.6
II	4.80	4.95	5.02	5.1	5.10	5.10	4.23	4.20	4.27	4.40	4.2	4.2	5.01	4.25	4.4
III	6.67	6.75	7.05	7.05	7.05	6.75	6.37	6.22	6.07	6.30	6.22	6.15	6.91	6.22	5.5

(a) The Roman numbers stand for the individual cast skins considered. All those of *B. furcata* came from a bare lime sink hole in Isabela, March 25. Under *Cannacria* I was obtained on the same date and place before mentioned. II, V and VI from Cartagena Lagoon, February 24 and August 20; III and IV from Cabo Rojo, February 24.
(b) Head missing or so broken that it could not be accurately measured.
(c) All measurements in millimeters.
(d) The tenth segment bears an additional very small hook in both species.
(e) The corresponding left and right having different numbers or unequal in length.
(f) Not given.

Coryphaeschna adnexa (Hagen)

(Pl. V, Fig. 4; Pl. VI, Fig. 7)

Length 41.5 mm.; abdomen 28.25 mm.

Large head, greatest width across the eyes 8 mm.; the latter large and rounded, their most proximal slightly sinuated margin 1.6 mm. from the occipital margin, measured from the greatest depth of the sinuation. Occiput emarginate, its proximal mid-point to a corresponding one on the vertex margin 1.4 mm., its width 5.25 mm. across. Maximum length across the head, back of the proximal margin of the eyes 6.25 mm. Ratio of the antennal segments: 1:1.5:2:1:1.5:1.5:1. The labium measures 7 mm. in length and 5 mm. wide; sides from hinge out more or less parallel for about 4 mm. where they broaden out to attain the maximum width of 5 mm. Very small setae along the finely serrated edges starting a little below the place where the broadening begins where there is besides the ridge of spinules a few of the latter on the inner surface of the labium; somewhat flattened along the margins where breadth is largest. Distal margin of medial lobe rather convex rising .5 mm. above horizontal line between bases of lateral lobes. A cleft .2 mm. deep and .15 mm. wide in the middle with two chitinized rounded teeth about .1 mm. from the edge of the cleft rising about .03 mm. above the margin. Hairs along the margin rising as high as the two teeth close to cleft. Lateral lobes with their inner lower margin denticulated beyond the curved proximal end, the small teeth increasing in size until they reach the large chitinized tooth at the distal end of the inner margin on the lower end of the nearly squarely truncate distal margin of the lateral lobe. This outer distal margin is also denticulated, but the teeth are small and compare only with those at the proximal end of the ventral margin of the lateral lobes; the large ventral tooth is about ⅓ the length of the truncate distal margin. Very small setae along the middorsal line of the movable hooks.

The legs with a few hairs on them; possibly some of the latter even lost during dryness, but by no means are they hairy. Measurements of femur, tibia, and tarsus as follows: I 3.6:4.25:2; II 5.1:4.75:2; III 6:6:2.5. Posterior wing pads 8.75 mm.

Abdomen elongate, widest at the sixth segment measuring 7.3 mm. Spines on segments 6, 7, 8, 9 having a length of .25; .6; .75; and .5 respectively. Lateral margin of spine bearing segments serrate with fine setae in the notches. Gonapophyses on 8th segment 2.75 mm. long, reaching the hind border of segment nine; those on this latter segment 2 mm. long reaching beyond the hind margin. Lateral appendages 3.75 mm. long, more or less rounded and ending in a strongly chitinized sharp point; as long as the superior which is rounded at the tip. Inferior appendages the same length of lateral reaching a fraction of a millimeter beyond the superior, triquetral in shape, incurved tips chitinized but not as heavily as laterals.

Almirante Road, near Vega Baja, Km. 6.7, March 9, Dr. James G. Needham.

REMARKS

The preceeding description is based on a cast skin supposed to represent the last larval instar because it was dry and on a bulrush. A very thin mud film covered the surface hiding all possible color patterns.

A number of similar nymphs were obtained in Tortuguero Lake together with those of *Anax*. They are easily told from these latter ones, when alive, because they have white eyes, as well as by their abdominal appendages.

None of the living nymphs collected had attained the size of the described cast skin, but undoubtedly are the same species. The younger nymphs have a tendency to be darker in color than the older ones. Antennal segments 3 and 4 are brown in color as well as the distal end of the terminal one. The labia of the younger ones may show smaller additional teeth between the cleft and the two larger teeth mentioned in the description. The color pattern on the legs is variable also from completely paternless ones, through some of their femora marked with three rings and a brown or black spot about $\frac{2}{3}$ distant from the proximal end of the femora. These dots are the ones to hold most consistently throughout. The abdomen has no definite color pattern, but in the middle size nymphs there may appear on the sides two diagonally placed brown spots, most easily seen and occurring more frequently, on segments 5–8 although the anterior ones may show them also. A black dot on the ventral surface of the inferior appendages, close to the chitinized tip and separated from this by a less chitinized and equal to or slightly larger than the black spot itself.

Klots (1932) suggests the possibility of another species besides *C. adnexa;* since, as stated by her, this is not certain I have assumed this nymph to be the latter.[1]

ZYGOPTERA

Argiallagma minutum (Selys)

(Pl. IV; Pl. V, Figs. 1, 3; Pl. VI, Fig. 2)

Length 9 mm. + 4 mm. gills, abdomen 5.75 mm.

Head flattened, hind angles rounded with easily seen, sparsely placed spines. Antennal segments 1 and 2 with dark brown spots on their inner margins, close to the joint, also on distal outer margin of second segment. Proximal fourth of the third brown, the rest of the antenna with no markings. Ratio of antennal segments 1:1.1:2.5:1.8:1.1:.9:.7. Widest distance across the eyes 2.7

[1] See note at end. (page 85.)

mm. Labium with four mental and seven lateral setae. Distal margin of mentum more or less even, but beset with very minute teeth-like spines which give it the appearance of being finely denticulated. Inner margin of lateral lobe finely serrated; distal inner fixed tooth small and sharply incurved, notch between this and central distal lobe rather shallow and only half as wide as deep. Central terminal lobe squarely truncate with external third showing minute spines on border. Inner extreme close to fixed tooth, pointed.

Femur of first leg with two diffuse brown rings and proximal end tinged with the same color; the second with similar markings but deeper in color; on the third the pigment is not so heavy, but the rings may be easily seen. Tibiae with no definite rings, but brownish in color. Femur, tibiae and tarsi as follows: I 1.5 mm.; 1.5 mm.; 0.75 mm.; II 1.9 mm.; 2.0 mm.; 0.75 mm.; III 2.4 mm.; 2.5 mm.; 1.00 mm. Posterior wing pad 2.9 mm.

Dorsal surface of abdominal segments brown, mottled with numerous, small dots lighter in color. Middorsal area of segments with no dots on it and lighter in color than the rest, increasing in width from proximal margin of fifth segment and reaching its maximum on segment 10. About the middle of the segments 7, 8 and 9 and on the sides of the light middorsal areas, dark brown dots. Similar but fainter dots about ⅔ of the segment on 5 and 6. Lateral keels with spines. Female gonapophyses on 8 and 9, reaching beyond the distal margin of segment 10. The one on the 8th is the longest and that of the 9th with tips highly chitinized. Gills, lateral ones lanceolate, tapering to a point; more or less pigmented throughout with scattered larger brown dots. Heavier and larger pigmented areas on outer margins of distal half tending to form irregular bands. Tracheal branches pinnately arranged, being more numerous in upper half above central main trunk, than in lower area, pigmented and scarcely branched. Marginal spines about one-half the length of the gill.

Almirante Road, near Vega Baja, Km. 6.7, March 9, Needham and García-Díaz.

REMARKS

The description is based on a single specimen obtained in the same place where a series of adults were collected at the same time. One of the legs was cleared and showed the characteristic long spines of the genus.

Ceratura capreola (Hagen) (Supposition)

(Pl. V, Figs. 2, 5)

Length 9.5 mm. + 3.8–4.3 mm. gills; abdomen 6.1 mm.

Hind margins of head standing out more than usual with many spines easily seen. Greatest width across the eyes 3.3 mm. Segments one and two of the antenna brown in color, the rest with a very faintly tinge on their proximal ends. Ratio of the antennal segments 1:1.5:2:1.7:1.2:.9:.5. Labium

strong and large with one mental and six lateral setae. Distal margin slightly crenated with minute spines in crenulations close to base of lateral lobes, which becomes teeth-like as they approach to the center. Lateral lobes with straight smooth inner margin; the distal central margin between the fixed tooth and the movable hook slanting rapidly from the former to the base of the latter, slightly crenulated and having a few minute spinules on its central length.

Femora with dark colored proximal ends and two dark brown rings showing better on the first two than on the hind one. Tibiae with very fine hairs on their outer surfaces, more numerous than usual. The femur, tibia and tarsus measuring: I 1.6 mm.; 2.0 mm.; 0.8 mm.; II 2.25 mm.; 2.4 mm.; 1.1 mm.; III 2.75 mm.; 3.0 mm.; 1.2 mm.

Abdomen cylindrical; a light middorsal area on each segment, largest on 9 and 10. The rest of the segments dark brown in color with numerous setae, but no strong spines. Lateral keels conspicuous on segments 2–7, without spines, the distal ends of those on 2–5 white in color. Distal margins of segments 5–9 with dull white marks. Male ganopophyses reaching the middle of segment 10. Gills with practically no branches in the proximal third, those beyond, not greatly branched, pigmented and running more or less parallel to the margins, but rearward. Sides of gill gradually widening out for about half the distance, when they widen suddenly becoming abruptly to a point at the tip. Main trachea pigmented and a little pigment throughout the entire gill, with rounded, irregularly scattered, patches along the margins. Marginal spines of middle gill about one half the length of the gill with fine setae between the spines.

Río Piedras River, south of the Agriclutural Experimental Station. March 18 Needham and García-Díaz.

REMARKS

Four nymphs with the setal formula given were collected. One of them is too young and the other three are too old to show the venation.

Klots (1932) has described a nymph collected by Doctor Needham at Wismar, British Guiana, April 13, 1930. These nymphs differ in many details from the one described by Doctor Klots, but is only a supposition which is justified mainly on the basis of the size. The nymphs which I take for fully mature, because of the stage of development of the wing pads, are too small for any of the other species on the Island with the exception of *Argiallagma minutum* from which are easily distinguished by the setal formula. The measurements given are based on one of the nymphs since of the other three one is too young and the other two had their abdomen elongated due to poor preservation.

Enallagma civile (Hagen)

REMARKS

The nymph of this species was described by Doctor Needham and Cockerell (1903). Its absence in the collection struck me, more so when adults were collected and seen in many places where nymphs apparently were absent. Upon examining the venation of the wing pads of some nymphs believed to be *Ischnura ramburii* I found that M_1—M_2 arose in many of them between the 4th and 5th postnodals instead of between the 3rd and 4th. This suggested the possibility of some of these nymphs being those of *Enallagma civile*. This supposition was backed to a certain extent by some of those nymphs having three mental setae, other with three mentals and sometimes a rudimentary fourth one, while a few others would have four mental and lastly a rudimentary fifth one. These facts made it impossible to certainly distinguish *Enallagma civile* from *Isachnura ramburii*, since all other characters, including the gills, seem to intergrade and be similar in the two species. The lengths of the second and third antenal segment are somewhat reliable in distinguishing them. In *Enallagma* the third segment is fully one and a half times longer than the second while in *Ischnura* it is slightly longer, but never as in the first case. The Puerto Rican species, as it often happens with corresponding northern and southern ones, seems to be smaller in size than that described by Needham and Cookerell. Were it not for this, it could be easily told apart because none of Puerto Rican species attain the size of the original description. A reared series of both species will be the only possible final criteria.

Enallagma coecum (Hagen)

Length 12–12.5 mm. + 4.3 mm.–4.5 mm. gills; abdomen 8–8.3 mm.

Dorsal surface of head back of posterior margin of eyes dotted with brown spots which are the bases of small spines; hind angles smooth and but with a few spines on margin. Widest distance across the eyes 3.1 mm. First and second antennal segments brown, proximal and distal ends of third segment tinged with brown with a lighter middle area; segments 4, 5 and 6 with proximal ends tinged with brown also. Ratio of antennal segments 1:1:1.5:.9:.5:.3:.2. Labium with one mental and three lateral setae. Distal margin of mentum irregularly serrated for about one-fourth its distance from the base of lateral lobe, from there on to the center more regularly serrated with minute spinules set in the notches. Inner margin of lateral lobe uneven: deep notch between terminal hook and central distal portion between the latter and movable hook. Distal margin of this central lobe broken into 3–5 irregular teeth.

Femora of all legs with an apical brown ring, rest of the legs without markings. Inner proximal end of tibiae with a chitinized spine-like outer mar-

gin. Distal end of tarsus darker in color than the rest. Femora, tibia and tarsus: I 1.55 mm.; 1.9 mm.; .9 mm.; II 2.1 mm.; 2.2 mm.; 1 mm.; III 2.7 mm.; 2.75 mm.; 1.15 mm.; Posterior wing pads 3.9 mm.

Abdomen covered with numerous spines. A middorsal thin line which broadens posteriorly on segment 8, 9 and 10, where the clear area covers most of the dorsal surface. An area, darker than the rest of the segment, on the sides of the clear line, widest in segments 6 and 7 and hardly noticeable on the sides of clear area on segment 10. On the distal middorsal margins of segments 4–9 two brown spots separated by the clear central line. On the same margins and half way between dorsal dots and lateral keel a small dark dot on segments 4, 5, and 6. Lateral keels well developed on segments 2–8 with easily seen spines on the entire keel. Gonapophyses of female on 8 and 9, reaching distal end of segment 10, those of male as far as the middle of segment 10. Gills jointed, marginal spines extending to the joint, the rest of the margin with very final setae. A main central trachea with few rather simple lateral branches most numerous beyond the joint, on proximal half some pigmented tracheal branches. Pigment on proximal half close to central trachea; on distal half covering a broader area in irregular patches, sometimes tending to form 2 or 3 cross bands. The tips of unbroken gills end in a point but in the majority this tip breaks and the gill ends in an acute angle.

Adjuntas, March 28, Needham and García-Díaz.

REMARKS

Klots (1932) in discussing the species *E. coccum* and *E. cardenium* after a most careful and exact consideration of the male appendages as well as indicating other differences in the adults did not feel like making them two different species, but the second a subspecies of the first. The rearing of a male and female specimen by Doctor Needham and myself and a comparison of these nymphs with the description of the one by Byers (1930), tend to make a valid species for *Enallagma cardenium*. The differences between the described nymphs as well as those of the adults indicated by Klots, it is believed, substantiate this view.

The nymphs upon which Klots based her description as *Telebasis dominicanum* were, I think, not fully developed which may account for discrepancies in both descriptions.

Enallagma cultellatum (Hagen)

(Pl. V, Figs. 6, 7)

Length 11.5 mm. + 5 mm. gills; abdomen 7.5–8 mm.

Head much wider than long; eyes standing out laterally from hind margins with the emargination where the former and the latter meet deeper than usual; hind margins slightly spinulose and not smoothly rounded, but tending to form a wide angle at their extreme outer points as they curve into proximal

margin of eyes. First segment of the antenna and two-thirds of the second brown in color; the rest with no markings. Ratio of antennal segments: 1:0.8:1.6:1.0:0.6:0.4:0.3. Labium with 3 + 1 mental and 5 lateral setae. Central distal portion of mental lobe smoothly rounded with its edge crenulated, with small denticles set in the crenulations, most easily seen in central half of the entire margin. Inner margin of lateral lobe minutely crenulated. A deep broad, slightly deeper than broad, notch between the terminal fixed tooth and the distal central portion of the lateral lobe; this latter one broken into three well defined teeth followed by an irregular broken surface and a straight outermost side; the first tooth about twice the size of the following one.

Legs slender, the femora with distal or apical brown rings, their proximal ends also brown; tibiae with a proximal incomplete brown ring showing best on the ventral surface, the rest of the legs with no color pattern. Measurements of femur, tibia and tarsus: I 1.5 mm.; 1.8 mm.; 0.8 mm.; II 2.0 mm.; 2.1 mm.; 0.9 mm.; III 2.6 mm.; 2.7 mm.; 1.00 mm.

Abdomen with lateral keels strongly developed on segments 2–8, spiny, ending at their distal end in two strong chitinized spines in segments 2–7; segment 8 with only one distal lateral spine; segment 9 without a well marked lateral keel, but showing a single strong terminal spine in place corresponding to preceding ones. On middorsal line of segments 4–9, on distal margin, two spines larger and more strongly chitinized than the rest, on middorsal surface of segment 2 near its proximal margin a close tuft of setae; a smaller and similar tuft on segment one. Gonapophyses of female on 8 and 9 not reaching but close to distal margin of segment 10. Gills jointed about half-way their length, with pigmented branched tracheae. Marginal spines to the joint terminating in one thicker than the other with a strongly chitinized base.

Tortuguero Lake, February 14, 15, Needham and García-Díaz.

REMARKS

A reared male and a few cast skins served as a basis for the description. No other nymphs were collected. The measurements are mainly from the cast skins. The color pattern of the gills of the living nymphs may very from the one given herein.

A very young nymph from Caño Tiburones shows on its gills the characteristic spine of the marginal ones. The gills have many transparent areas alternating with incomplete, irregular transverse, light brown areas. Lateral branches few, branched and pigmented.

Telebasis vulnerata (Hagen)

(Pl. V, Figs. 8, 9)

Length 12.5 mm. + 4.5 mm. gills; abdomen 7.5 mm.

Head with large conspicuous eyes, posterior margins smoothly rounded and slightly spinulose. Ratio of antennal segments 1:1.5:2.6:1.8:1.1:.8:.5 The second segment with a small distal outwardly placed dark spot. The rest with no markings. Extremely fine setae on papillae on the middle of segment three

as well as on its distal end where they are more numerous. Similar papillae and setae on distal ends of segments 4–7. Labium reaching the middle coxae; three mental setae with many minute ones scattered about; six easily seen lateral ones with an additional weaker and smaller one close to the base of lateral lobe. Distal margin of mentum smooth with teeth-like spinules separated by a distance at least equal to the size of the spinules. Central distal margin of lateral lobe somewhat truncate with a slight notch close to fixed tooth and on its outer two thirds bearing spinules similar to those of distal margin of mentum.

Femora with two brown rings separated by three nearly equal light areas. The first brown ring on the first femora not so clearly marked at the others. Extreme proximal end of the tibiae tinged with brown as well as distal end of femora. Distal end of tibiae light in color followed by a brown ring, rest of tibia clear. Femora, tibiae and tarsi as follows: I 2.0 mm.; 2.4 mm.; tarsi missing; II 2.6 mm.; 2.7 mm.; 1.1 mm.; III 3.3 mm.; 3.4 mm.; 1.4 mm.; Posterior wing pads 4 mm.

Abdomen with well developed spines on the lateral keels of segments 4, 5, 6, 7 and 8 though less numerous on the first and last of those mentioned. The distal margins of these segments decidedly brown with light clear areas. Two brown broken lines close to the lateral keels. Dorsal surface of some segments sparsely covered with short spines most numerous in segments 6, 7, and 8. The tenth segment decidedly circular, the distal margin fringed with short, strong chitinized spines. Female gonapophyses on 8th and 9th segments nearly reaching distal margin of segment 10. Gills about three and a half times as long as wide; dorsal marginal spines of middle gill, one half its length, on the spaces between the spines very fine setae varying in number, but most numerous on distal ones; the main trachea pigmented with light and dark places, lateral branches not very numerous, but strong and more branched towards the basal portion of the gill, pigmented. Basal half of gill with little pigment when compared with distal one where it is irregularly scattered in darker blotches with lighter areas between.

Maricao Forest Reserve, Camp Buena Vista, March 24, Needham.

REMARKS

A single reared female specimen, on the cast skin of which is based the description. No more nymphs collected. As indicated before I think the nymph described under this name by Klots (1932) is *E. coecum.*

TABLE II. THE ALTITUDINAL DISTRIBUTION OF ODONATA: NYMPHS AND ADULTS

Species	Nymphs			Adults		
	No. of Sta.	Min. Alt.	Max. Alt.	No. of Sta.	Min. Alt.	Max. Alt.
ANISOPTERA						
1. Acanthagyna nervosa	*1	80	....	....	....	....
2. Aeschna cornigera	*1	2350+	....	1	1968	....
3. Anax amazili	1	80	....	....	....	....
4. Anax junius	5	**0	1968	9	0**	1896
5. Cannacria herbida	*1	20	....	11	0	300
6. Brachymesia furcata	*1	164	....	1	300	....
7. Coryphaeschna adnexa	3	0	164	3	0	300
8. Dythemis rufinervis	5	80	2000+	18	0	1896+
9. Erythemis plebeja	....	....	....	6	0	500
10. Erythrodiplax berenice naeva	....	....	....	1	....	60
11. Erythrodiplax c. justiniana	*1	....	164	12	0	1896
12. Erythrodiplax minuscula	....	....	....	2	20	80
13. Erythrodiplax umbrata	2	0	80	17	0	1050
14. Gynacantha trifida	....	....	....	....	....	....
15. Idiataphe cubensis	1	....	0	1	0	....
16. Lepthemis vesiculosa	3	0	300	18	0	1050
17. Macrothemis celeno	4	100	1300	18	0	2000+
18. Miathyria marcella	1	....	300	4	0	86
19. Micrathyria aequalis	....	....	....	1	20	....
20. Micrathyria didyma didyma	....	....	....	....	....	....
21. Micrathyria dissocians	*1	....	300	8	20	233
22. Micrathyria hageni	....	....	....	....	....	....
23. Orhemis ferruginea	4	80	1300	18	0	1980
24. Pantala flavescens	....	....	....	8	0	1500
25. Perithemis domitia	2	80	164	3	20	164
26. Scapanea frontalis	3	500	1968	10	16	2000+
27 Tramea abdominalis	1	....	20	17	0	1896
28. Tramea binotata	....	....	....	4	0	500
29. Tramea onusta	....	....	....	8	0	104
ZYGOPTERA						
30. Anomalagrion hastatum	2	80	....	11	0	500
31. Argiallagma minutum	*1	....	....	2	....	....
32. Ceratura capreola	0	....	....	3	....	500
33. Enallagma civile	0	....	....	11	0	1896
34. Enallagma coecum	10	80	1050	23	0	2000+
35. Enallagma cultellatum	1	0	....	1	0	....
36. Ischnura ramburii	3	0	300	18	0	300
37. Leptobasis vacillans	....	....	....	....	....	....
38. Lestes forficula	8	0	1461	10	0	500
39. Lestes scarlaris	....	....	....	2	0	500
40. Lestes spumarius	....	....	....	1	....	17
41. Protoneura capillaris	....	....	....	1	....	80
42. Telebasis dominicanum	....	....	....	9	17	1968
43. Telebasis vulnerata	1	....	2350	15	16	2000

* Nymphs designated by supposition.

** Sea level.

TABLE III. BIRDS FEEDING ON ODONATA AS SHOWN BY STOMACH CONTENTS

	Bowdish, 1902				Danforth, 1926				Wetmore, 1915; 1927			
	Anisoptera		Zygoptera		Anisoptera		Zygoptera		Anisoptera		Zygoptera	
	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
1. Butorides virescens cubanus (Oberholser) (Cuban Green Heron, Martinete)									some	1		several
2. Butorides virescens maculatus (Boddaert) (West Indian Green Heron, Martinete)					32. %			10 %				
3. Comsothlypis americana *usneae* (Brewster) (Northern Parula Warbler, (Reinita)					2.6%							
4. Crotophaga ani (Linnaeus) (Ani, Judio)					2.6%			1.4%		.5%		
5. Dendroica petechia bartholemica Sundeval (Porto Rican Yellow Warbler, Reinita)										1.3%		
6. Egretta candidissima candidissima (Gmelin) (Snowy Egret, Garza blanca)							4 %	15 %	2			
7. Erismatura alleni (Danforth) (Allen's Ruddy Duck, Chorizo)					4.5%							
8. Falco columbarius columbarius (Linnaeus) (Pigeon Hawk, Gavilán, Lechuza)						73 %	12 %					
9. Florida coerula coerulescens (Latham) (Little Blue Heron, Garza Azul)									2			
10. Gelochelidon nilotica (Gmelin) (Gull-billed Tern, Gaviota)					4%							
11. Helodromas solitarius solitarius (Wilson) (Solitary Sandpiper, Putilla)									50%			
12. Herodias Egretta (Gmelin) (Egret, Garzón blanco)										3		
13. Hirundo rustica erythrogaster (Boddaert) (Barn Swallow, Golondrina)								5.3%				
14. Hydranassa tricolor ruficelis (Goose) (Louisiana Heron, Garza de vientre blanco)					5%							
15. Hydrochelidon nigra surinamensis (Gmelin) (Black Tern, Gaviota prieta)						3.8%		2%				
16. Holoquiscalus niger brachypterus (Cassin) (Porto Rican Crackle, Chango)						1.3%						
17. Marila affinis (Eyton) (Lesser Scaup Duck, Pato silvestre)									69%			
18. Melanerpes portoricensis (Daudin) (Porto Rican Woodpecker. Carpintero)		1										
19. Mimus polyglottos orpheus (Linnaeus) (Jamaican Mockingbird, Ruiseñor)		1										
20. Oxyechus vociferus rubidus Riley (Antillean Killdeer, Playero)										3.9%		
21. Podilymbus podiceps antillarum (Bangs) (Antillean Piedbilled, Zaramago)					8%				2	1.3%		
22. Progne dominicensis (Gmelin) (Caribbean Martin, Golondrina de Iglesis)										8%		
23. (Seirus novaboracensis novaboracensis (Gmelin) (Northern Water Thrush, Pizpita)								10				
24. Seirus motacilla (Vieillot) Louisiana Water Thrush, Pizpita chica)										1		
25. Totanus melanoleucus (Gmelin) (Greater Yellow Legs, Playante)					65.3%							
26. Tyrannus dominicensis dominicensis (Gmelin) (Gray Kingbird, Pitirre)					catches adults on the wing							

SUMMARY OF TABLE III.

	Bowdish, 1902	Danforth, 1926	Wetmore, 1916; 1927
Total number of species of birds reported feeding on insects...	30	53	69
Species feeding on odonates....................................	2	15	12
Percentages of species preying on odonates.....................	6.6	28.3	17.4

NOTE

While the preceding pages were in press specimens were collected which alter some records and points of view taken at the time the work was done.

Acanthagyna nervosa Rambur

Specimens were collected in Tortuguero Lake, west end Oct. 31. The end of the lake was completely dry. While collecting, late in the afternoon, it became quite dark when a specimen was seen. Presently other specimen appeared and seven were collected. They fly close to the ground, from 12 to 18 inches, among the clumps of grasses. Once seen it is most probable to capture them, even if missed once or twice, because they keep flying slowly around.

The collecting of these specimens in this place questions the supposition of the numph described under *Coryphaeschna adnexa*. The adults were collected exactly on the same place where the nymphs believed to be the same as that dscribed were collected. Could these nymphs be those of *Acanthagyna nervosa* and not those of *Coryphaeschna adnexa?*

Gynacantha trifida (Rambur)

Specimens of this species were captured for the first time in Ameryjul, a small farm on the Trujillo Alto road Km. 1.2, Oct. 9, at dusk, close to a small creek east of the main road. Another specimen was caught in the same place Dec. 8 at 5:00 P. M. Two other specimens were obtained about four kilometer from the place: one at home, Stop 38½ Hato Rey, Nov. 18, which flew into the bath room and another found in a room of the Stahl building in the University by Mr. R. Córdova Marqués, Dec. 20.

The adults appear late in this afternoon. They are very rapid flyers making it nearly impossible to capture them. They do not fly usually in the open but keep "nosing" into the higher plants and bushes. Their somber colors make it some times impossible to distinguish them and only their flight makes them visible. I have never seen one standing still. Now and then they dart up into the open space above, reaching an altitude of 30 feet or more.

The collection of the specimen at Stop 38½, Hato Rey, verifies the statement made on page 55. The presence of adults in the mentioned area questions, in view of the statements made under *Acanthagyna* in this note, Klots' (1932) assumption about the nymph believed by her to be that of *Acanthagyna.*

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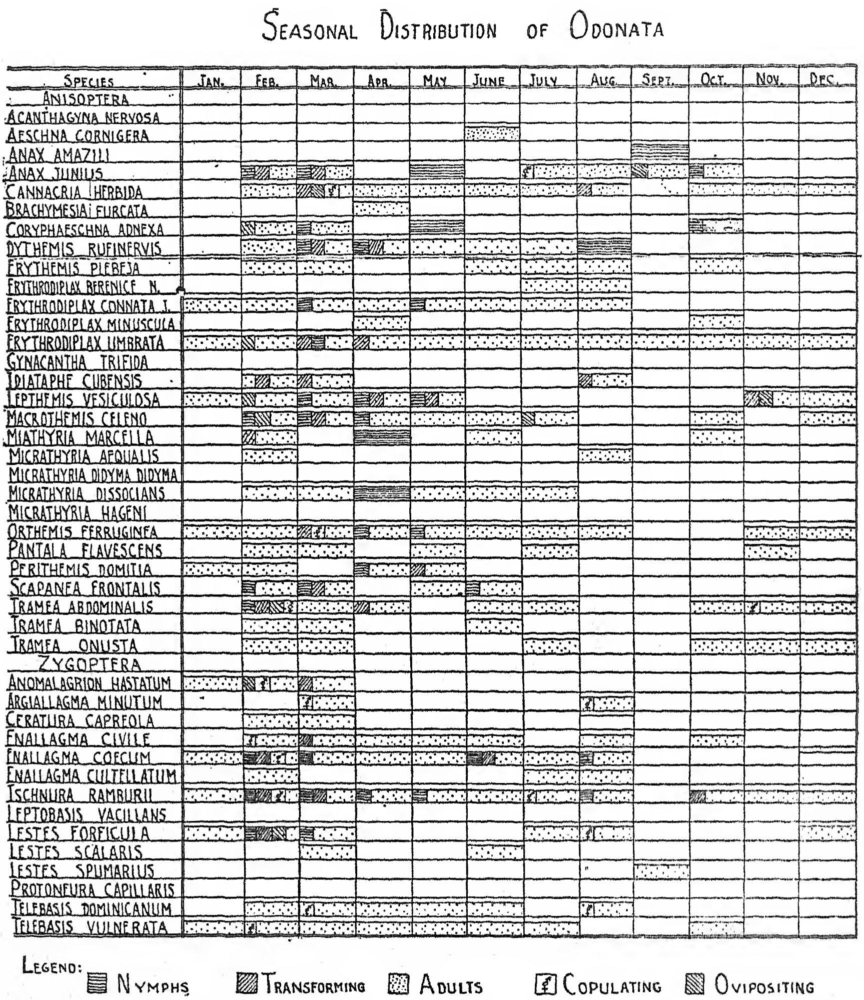
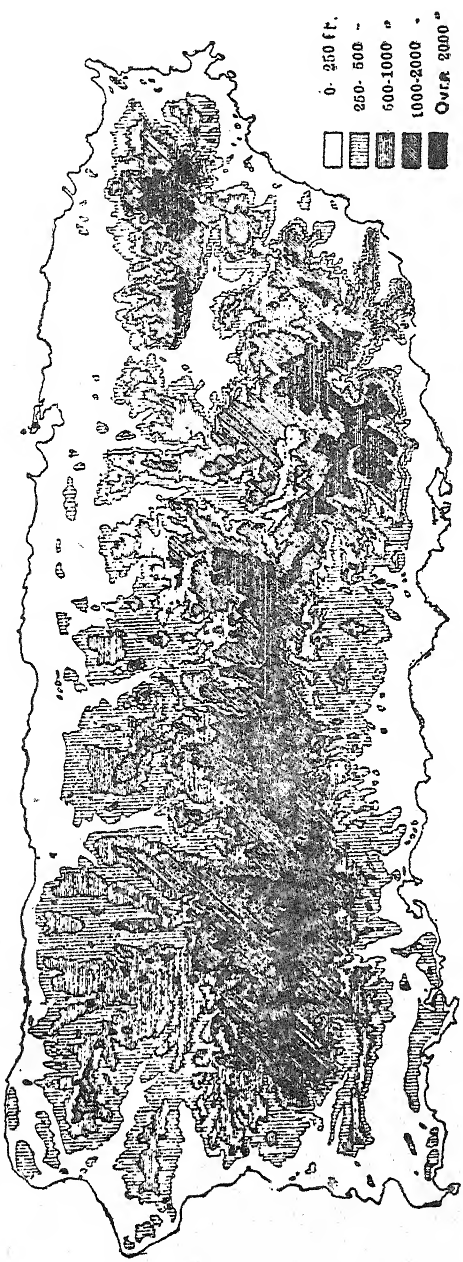

SEASONAL DISTRIBUTION OF ODONATA
SPECIES
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
ANISOPTERA
ACANTHAGYNA NERVOSA
AESCHNA CORNIGERA
ANAX AMAZILI
ANAX JUNIUS
CANNACRIA HERBIDA
BRACHYMESIA FURCATA
CORYPHAESCHNA ADNEXA
DYTHEMIS RUFINERVIS
ERYTHEMIS PLEBEJA
ERYTHRODIPLAX BERENICE N.
ERYTHRODIPLAX CONNATA J.
ERYTHRODIPLAX MINUSCULA
ERYTHRODIPLAX UMBRATA
GYNACANTHA TRIFIDA
IDIATAPHE CUBENSIS
LEPTHEMIS VESICULOSA
MACROTHEMIS CELENO
MIATHYRIA MARCELLA
MICRATHYRIA AEQUALIS
MICRATHYRIA DIDYMA DIDYMA
MICRATHYRIA DISSOCIANS
MICRATHYRIA HAGENI
ORTHEMIS FERRUGINEA
PANTALA FLAVESCENS
PERITHEMIS DOMITIA
SCAPANEA FRONTALIS
TRAMEA ABDOMINALIS
TRAMEA BINOTATA
TRAMEA ONUSTA
ZYGOPTERA
ANOMALAGRION HASTATUM
ARGIALLAGMA MINUTUM
CERATURA CAPREOLA
ENALLAGMA CIVILE
ENALLAGMA COECUM
ENALLAGMA CULTELLATUM
ISCHNURA RAMBURII
LEPTOBASIS VACILLANS
LESTES FORFICULA
LESTES SCALARIS
LESTES SPUMARIUS
PROTONEURA CAPILLARIS
TELEBASIS DOMINICANUM
TELEBASIS VULNERATA
LEGEND:
NYMPHS
TRANSFORMING
ADULTS
COPULATING
OVIPOSITING

FIG. 1



PHYSIOGRAPHIC MAP OF PUERTO RICO

FIG. 2

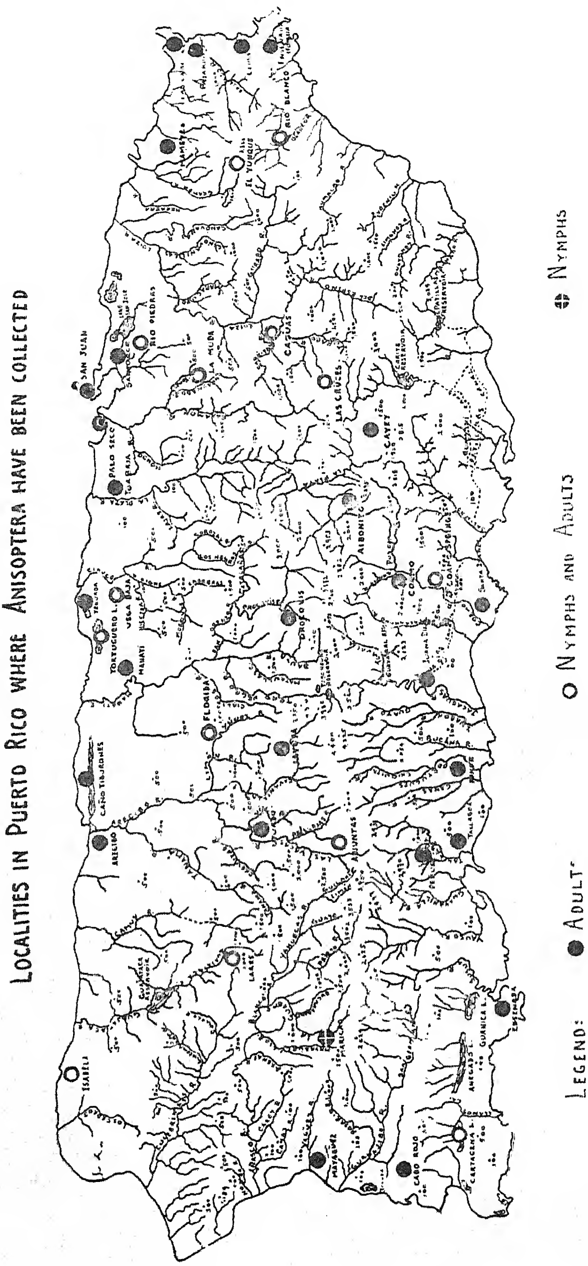

LOCALITIES IN PUERTO RICO WHERE ANISOPTERA HAVE BEEN COLLECTED
SAN JUAN
SANTURCE
RIO PIEDRAS
PALO SECO
TOA BAJA
TORTUGUERO L.
VEGA BAJA
MANATI
CAÑO TIBURONES
ARECIBO
ISABELA
EL YUNQUE
RIO BLANCO
CAGUAS
LAS CRUCES
CAYEY
AIBONITO
COAMO
OROCOVIS
FLORIDA
ADJUNTAS
LARES
PONCE
MAYAGUEZ
CABO ROJO
ENSENADA
GUANICA L.
LEGEND:
ADULTS
NYMPHS AND ADULTS
NYMPHS

FIG. 3

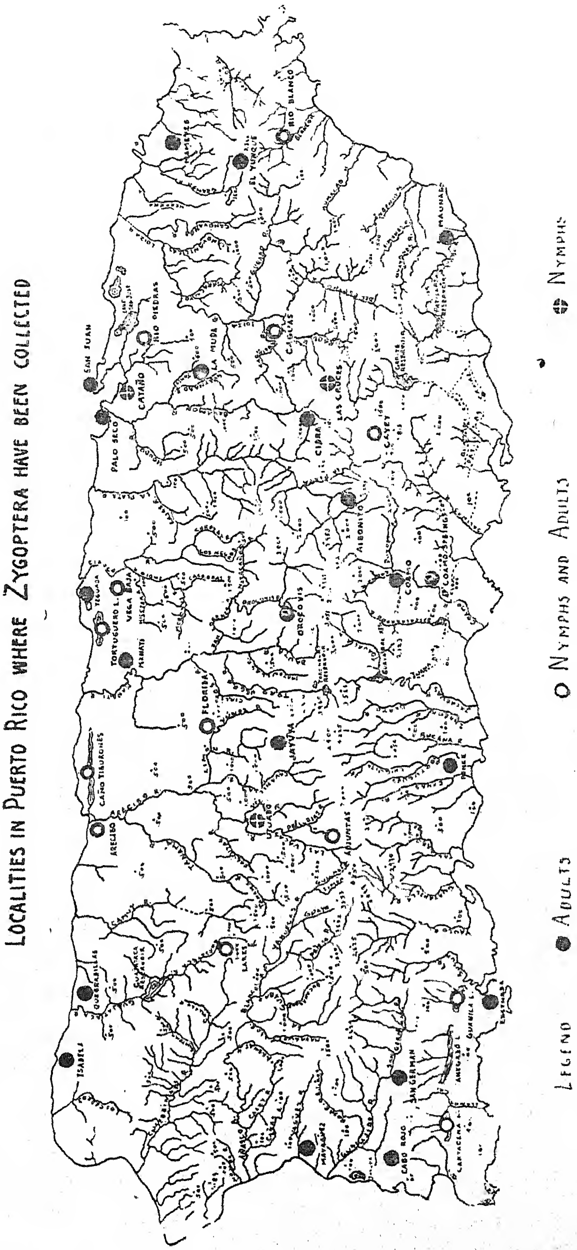

LOCALITIES IN PUERTO RICO WHERE ZYGOPTERA HAVE BEEN COLLECTED
LEGEND
ADULTS
NYMPHS AND ADULTS
NYMPHS
SAN JUAN
CATAÑO
RIO PIEDRAS
PALO SECO
CAGUAS
LAS CRUCES
CIDRA
CAYEY
AIBONITO
COAMO
OROCOVIS
VEGA BAJA
TORTUGUERO L.
MANATI
FLORIDA
JAYUYA
UTUADO
ADJUNTAS
ARECIBO
CAÑO TIBURONES
LARES
QUEBRADILLAS
ISABELA
MAYAGUEZ
SAN GERMAN
CABO ROJO
PONCE
ENSENADA
EL YUNQUE
RIO BLANCO
MAUNABO

FIG. 4

Appendix A

The following is a record of the material collected in Puerto Rico together with the one discussed on the preceding pages. As stated before, I feel a deep and great obligation for the specialists who most kindly have made the determinations. Dr. C. P. Alexander determined the Tipulidae; Dr. C. Betten the Trichoptera—this order has been worked only to genera due to lack of time on my part to take advantage of Doctor Betten's help; Dr. W. T. M. Forbes the Lepidoptera; Dr. R. Matheson the Culicidae; Dr. P. N. Musgrave the Dryopidae; Dr. A. J. Mutchler the Dytiscidae, Gyrinidae and Hydrophilidae; Dr. J. G. Needham the Odonata; and Dr. J. R. Traver the Ephemeroptera. Dr. O. A. Johannsen is working the rest of the Nemocera, and Dr. H. B. Hungerford the aquatic Hemiptera. I have still some material which will be submitted, in the near future, to other specialists.

COLEOPTERA

Dryopidae: det. Dr. P. N. Musgrave.

1. *Cylloepus danforthi* Musgrave.
2. *Neoelmis gracilis* Musgrave.
3. *Phanocerus* hubbardi** Schaeffer.

Dytiscidae: det. Dr. A. J. Mutchler.

4. *Bidesus** sp.
5. *Copelatus posticatus* F.
6. *Hydrocanthus iricolor* Say.
7. *Laccophilus bifasciatus* Chevrolat.
8. *Laccophilus proximus* Say.
9. *Pachydrus brevis* Sharp.
10. *Pachydrus globosus* Aube.
11. *Rhantus* calidus** F.
12. *Thermonectes basillaris* Harris.
13. *Thermonectes circumscriptus* Latreille.
14. *Thermonectes margineguttatus* Aube.

Gyrinidae: det. Dr. A. J. Mutchler.

15. *Dineutes metallicus* Aube.
16. *Dineutes longimanus portoricensis* Ochs.
17. *Gyrinus rugifer* Regimbart.

Hydrophilidae: det. Dr. A. J. Mutchler.

18. *Berosus guadaloupensis* Fleut. and Salle.
19. *Berosus tesselatus* Chevrolat.
20. *Derallus* rudis** Sharp.
21. *Enochrus nebulosus* Say.
22. *Enochrus ochraceus* Melsh.
23. *Hydrophilus insularis* Chevrolat.

---

* New record of genus and species based on material collected.

24. *Hydrophilus ater intermedius* Jacq. Duval.
25. *Nechydrophilus* phallicus** Orohymont.
26. *Ochthebus* sp.
27. *Paracymus* subcupreus?** Say
28. *Pelosoma** sp.
29. *Phaenotypus* palmarum** Schwarz.
30. *Tropisternus collaris* F.
31. *Tropisternus lateralis* F.

DIPTERA

Culicidae: det. Dr. R. Matheson.

32. *Chaoborus* festivus** D. & S.
33. *Culex antillum-magnorum* Dyar.

Tipulidae: det. Dr. C. P. Alexander.

34. *Dolichopeza (Megistomastix) acutiloba*** Alex.
35. *Dolichopeza (Megistomastix) obtusiloba*** Alex.
36. *Erioptera (Mesocyphona) caloptera* Say.
37. *Erioptera (Mesocyphona) portoricensis* Alex.
38. *Gonomyia (Lipophleps) bicornuta* Alex.
39. *Gonomyia (Lipophleps) monocantha*** Alex.
40. *Gonomyia (Lipophleps) orthomera*** Alex.
41. *Gonomyia (Lipophleps) pleuralis* (Will.)
42. *Gonomyia (Lipophleps) subterminalis* Alex.
43. *Gnophomyice diazi*** Alex.
44. *Helius (Helius) albitarsis* O. S.
45. *Hexaloma (Eriocera) trifasciata* (Boder).
46. *Limonia (Geranomyia) antillarum* Alex.
47. *Limonia (Dicranomyia) brevivana torrida* Alex.
48. *Limonia (Neolimnobia) diva* Schiner).
49. *Limonia (Dicranomivia) distans* O. S.
50. *Limonia (Rhipidia) domestica* O. S.
51. *Limonia (Rhipidia) tetraleuca*** Alex.
52. *Limonia (Geranomyia) subrecisa* Alex.
53. *Polymera (Polymera) geniculata* Alex.
54. *Shannonomyia leonardi* Alex.
55. *Shannonomyia triangularis* (Alex.)
56. *Toxorhina (Toxorhina) fragilis* Lw.
57. *Trentepholia (Paramongoma) niveitarsis* Alex.

EPHEMEROPTERA: det. Dr. J. R. Traver.

Baetidae.

58. *Baetis* garcianus*** Traver.
59. *Baetis* spp.
60. *Borinquena** carmencita*** Traver.
61. *Borinquena contradicens*** Traver.
62. *Caenis** sp.
63. *Callibaetis completa* Banks.
64. *Cloeodes** maculipes*** Traver.

---

* New record of genus or species based on material collected.
** New genera and species based on material collected.

65. *Cloeodes portoricense*** Traver.
66. *Cloeodes consignatum*** Traver.
67. *Cloeodes* sp.
68. *Neohagenulus*** *julio*** Traver.
69. *Neohagenulus tinctus*** Traver.
70. *Neohagenulus* sp.

LEPIDOPTERA: det. Dr. W. T. M. Forbes.

*Arctiidae.****
Progona pallida Moschler.
*Cosmopterigidae.****
Eriphia? sp.
*Phaloniidae.****
Phalonia sp.
Pyralidae.
71. *Argyrectis sumptuosalis* Moschler.
72. *Nymphula rugosalis* Muschler.
*Tineidae.****
Achanodes sp.
Homostinea? tischeriella? Walsingham.
Mea incudella Forbes.
Protodarcia sp.
*Tortricidae.****
Balbis excitana? Moschler.
Epiblema sp.

TRICHOPTERA: det. Dr. C. Betten.

Helicopsychinae.
73. *Helicopsyche* sp.
Hydropsychidae.
74. *Smicridea** sp.
*Hydroptilidae.**
75. *Hydroptila* sp.
76. *Neotrichia** sp.
77. New genera.**
78. *Oxyethira** sp.
Leptoceridae.
79. *Setodes**sp.
Philopotamidae.
80. *Chimarra albomaculata* Kolbe.
81. *Chimarra* sp.*
*Polycentropidae**
82. New genus.**
*Psychomyidae.**
83. *Lype** sp.
*Rhyacophilidae.**
84. *Atopsyche** sp.

---

* New record of genus or species based on material collected.
*** Not aquatic.

EXPLANATION OF PLATES

Plate IV

Argiallagma minutum (Selys)

Plate V

1. *Argiallagma minutum*, labium.
2. *Ceratura capreola*, labium.
3. *Argiallagma minutum*, gill.
4. *Coryphaeschna adnexa*, labium.
5. *Ceratura capreola*, gill.
6. *Enallagma cultellatum*, gill.
7. *Enallagma cultellatum*, labium.
8. *Telebasis vulnerata*, labium.
9. *Telebasis vulnerata*, gill.

Plate VI

1. *Brachymesia furcata*, part of abdomen with dorsal hooks and caudal appendages.
2. *Cannacria herbida*, part of abdomen, lateral, with dorsal hooks and caudal appendages.
3. *Brachymesia furcata*, part of the abdomen, lateral, with dorsal hooks and caudal appendages.
4. *Cannacria herbida*, antenna.
5. *Brachymesia furcata*, antenna.
6. *Cannacria herbida*, part of abdomen, with dorsal hooks and caudal appendages.
7. *Coryphaeschna adnexa*, caudal appandages.
8. *Anax amazili*, caudal appendages.

Plate VII

Wings of:

1. *Cannacria herbida.*
2. *Argiallagma minutum.*
3. *Idiataphe cubensis.*

PLATE IV

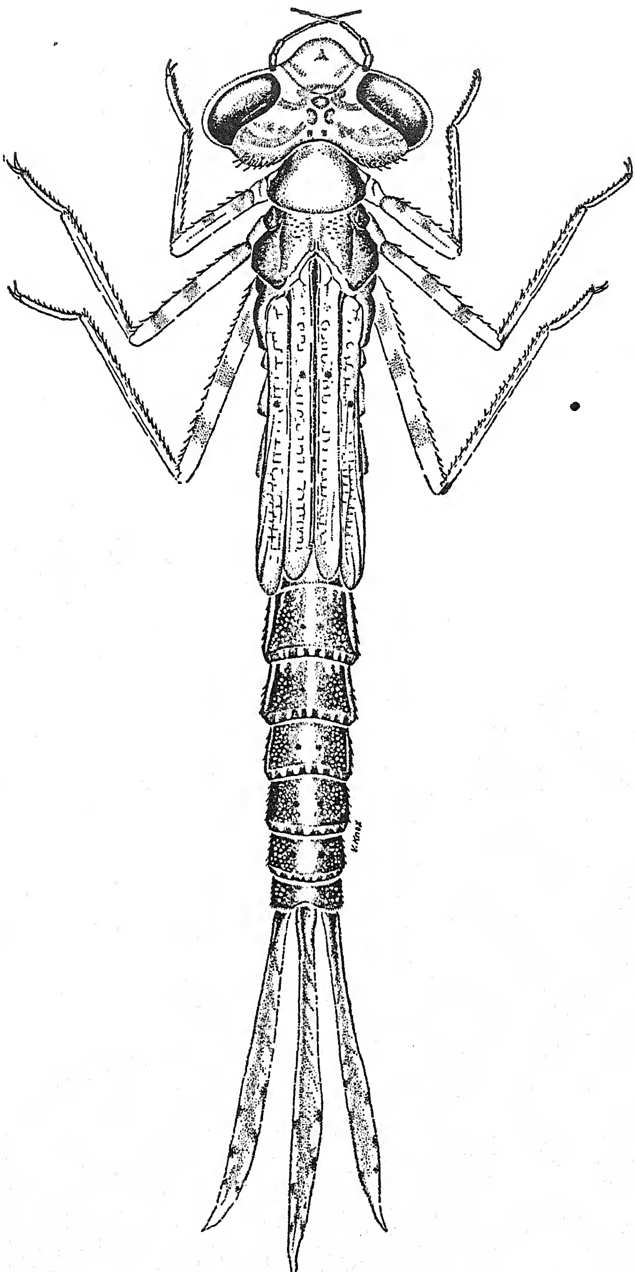
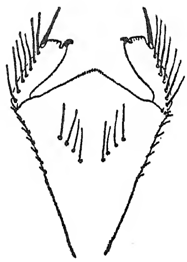


PLATE V



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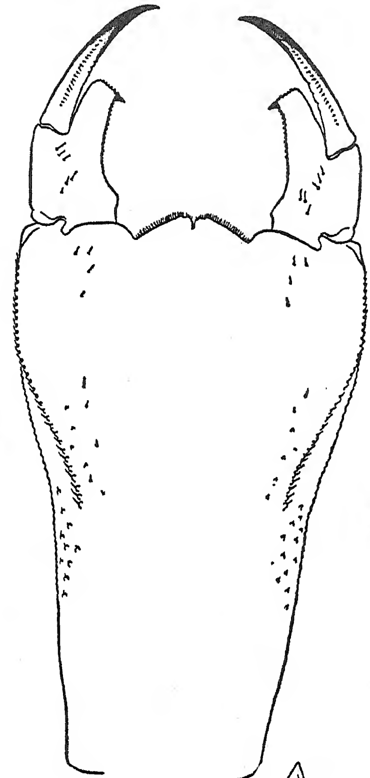

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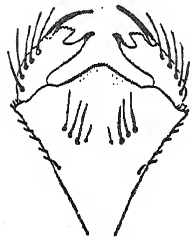

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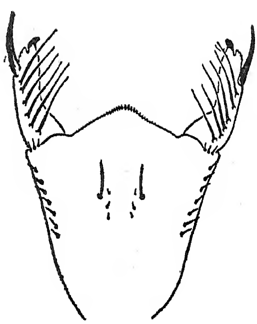

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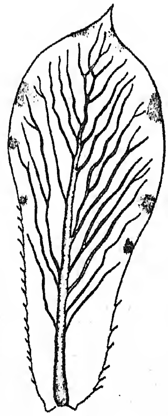

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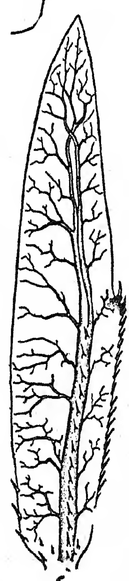

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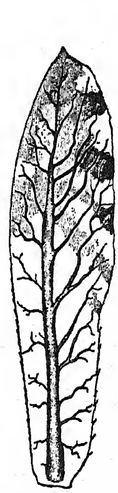

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PLATE VI

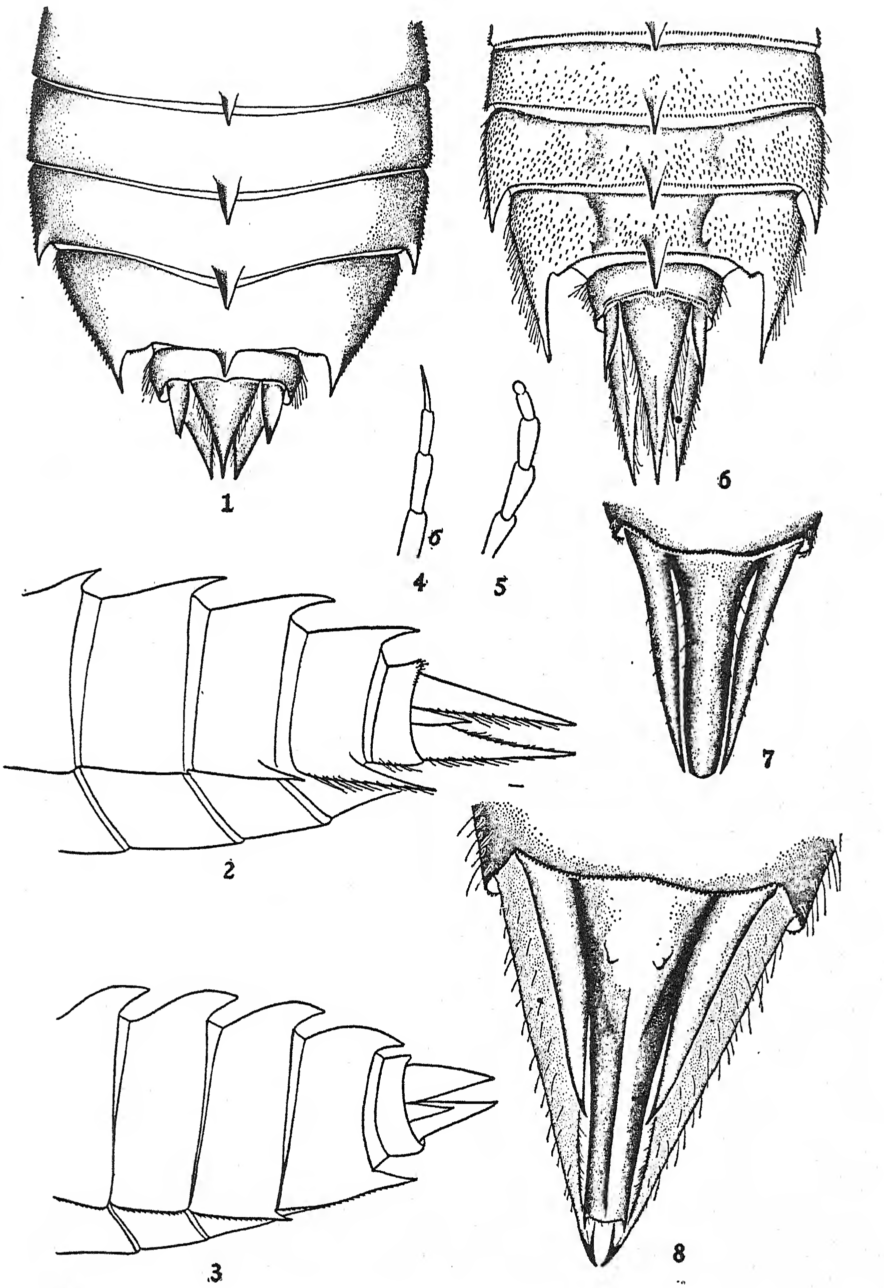
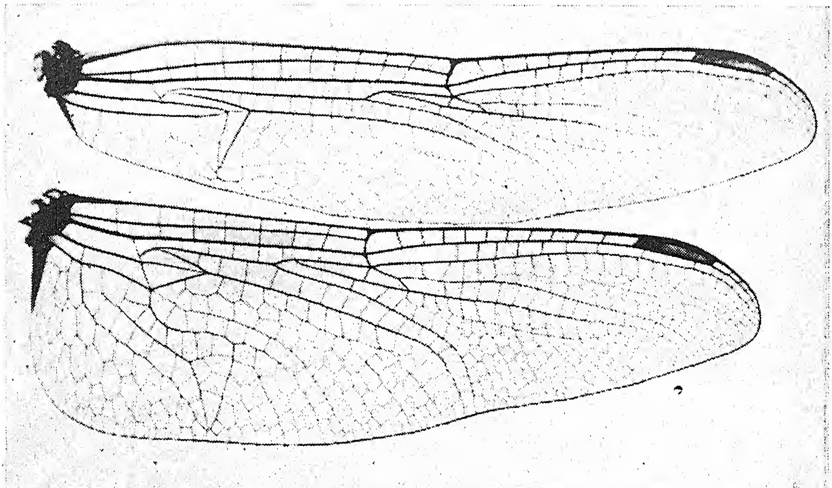


PLATE VII



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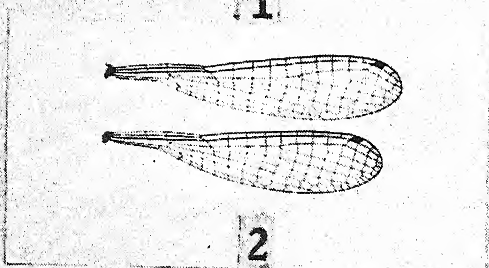

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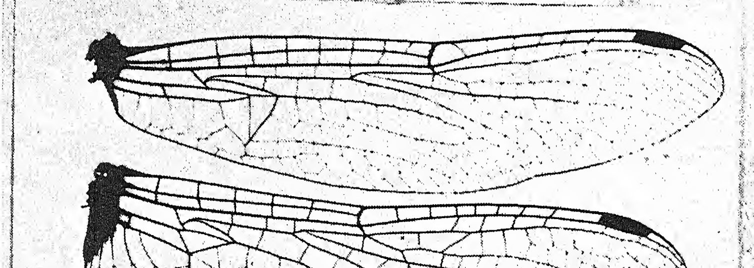

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THE NUTRITIVE VALUES OF SOME FORAGE CROPS OF PUERTO RICO [1, 2, 3]

1. Grasses

By J. H. AXTMAYER, C. F. ASENJO and D. H. COOK,
of the Department of Chemistry, School of Tropical Medicine, San Juan, P. R.

INTRODUCTION

The importance of the knowledge of the feeding value of forage crops in relation to the modern livestock and dairy industries is recognized.

Metabolic experiments carried out with lambs have proved to be an acceptable and practical method of determining nutritional indexes of feeds, such as the biological value, coefficient of apparent digestibility, etc., these serving to give the relative nutritive values of different forage crops when fed to ruminants.

Since no work of this kind has been undertaken before in Puerto Rico, we have had up to the present time no exact knowledge concerning the nutritive values of the different pastures used in our dairy and livestock industry.

The data presented here has been collected from experiments carried out during the years 1936 and 1937. We have tried to obtain information (similar to that collected in studies on forage crops in the United States) concerning the nutritive values of those pastures most commonly used on our Island, but in no way should this initial investigation be taken as a final dictum on the matter. In addition to the work which has been done to determine the nutritional indexes of the different grasses studied, we have also tried to obtain information regarding the influence such factors as the stage of maturity at the time of cutting, the cutting and the kind of fertilizer used, may have on the nutritive values of these grasses.

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[1] Cooperative project between the Agricultural Experiment Station of the University of Puerto Rico and the School of Tropical Medicine.

[2] Field work was conducted by the Experiment Station at Río Piedras.

[3] Study made possible from grant-in-aid of the Bankhead Jones Act of U. S. A. Congress 1936.

These factors are of enough importance to be the subject of a special investigation. Therefore, justification for presenting the present study lies in the hope that the data given here shall serve to indicate the problems to be solved in a systematic study of the nutritive indexes of the forage crops of our Island.

REVIEW OF THE LITERATURE

Although literature on the present subject is non-existent in Puerto Rico, it is so extensive in the States that it seems unnecessary for us to present more than a review of those studies from which we have taken our method. Sotola points out that the most accurate method of evaluating proteins at the present time appears to be that employed by Thomas and later modified by Mitchell (1). Mitchell performed a rigorous and extensive investigation of his method and came to the conclusion that it possessed a high degree of accuracy. It will be interesting to note that Mitchell used white rats as experimental animals. The method followed by Sotola (2) in his investigation on the biological value of the forage crops of the United States is similar to that recommended by Mitchell, being modified only in that Sotola used sheep instead of rats. The advisability of using sheep is clear, as results obtained in nutritive experiments with these animals have been shown to apply to cattle (3), and they are easier to work with.

The methods we followed in the determination of apparent coefficients of digestibility were the ones used by Sotola (4).

MATERIAL AND METHODS

The animals used in our experiment were native sheep whose ages ranged from six to eighteen months when purchased. We searched the Island in the hope of finding a pure breed of sheep, but could not find a single farm where the breeding or care of sheep were carried out under controlled conditions. The animals had been allowed to roam about the farms and could not be used during the first two or three weeks after they were brought to the laboratory because they were practically unmanageable.

The grasses studied were grown at the Experiment Station Farm of the University of Puerto Rico at Río Piedras. A field of approximately 2 acres was divided into seventy-two 1/40 acre plots, each treatment of the soil being replicated twelve times. One half of the replication was fertilized with a mixture of 400 pounds of

ammonium sulphate and 200 pounds of double superphosphate per acre, and the other half was fertilized with 400 pounds of ammonium sulphate alone per acre.

The stages of maturation at which these grasses were cut were just before or during the flowering periods.

The cutting was done early in the morning, the grasses being chopped into pieces ranging from 2 to 4 inches in length, put into jute bags and sent to us by truck, arriving usually at about 8 or 9 o'clock in the morning.

The detailed field conditions under which the grasses were grown are given in table A.

Experimental

Metabolism cages, 3½ feet long, 2 feet wide, and 3 feet high, similar to those used by Sotola (4) were constructed at the School shop. Each cage was provided with a double bottom for the collection of the urine and feces separately.

The animals, before beginning an experimental period, were kept during a preliminary period of 10 days on the ration to be tested. At the termination of this preliminary period, the animals were placed in the metabolism cages and the collection of the data for the experiment was begun. Each experiment lasted ten days.

The following data were collected during these ten-day experimental periods: 1. Initial and final weights of the animals at the start and the end of the experimental periods. 2. Weights of the feed consumed per day. 3. Weights of the feed refused per day. 4. Weights of the feces eliminated per day. 5. Volumes of the water consumed per day. 6. Volumes of the urine eliminated per day.

These data were collected practically at the same time every day, from 9 to 10 a.m., and aliquot samples of the feeds given, the refuse left, and the feces and urine eliminated, were taken for analysis.

All the solid samples collected were dried in an air oven at 100°C. The composite aliquot samples of the feces and urine were kept in the ice box. Xylol was added to the urine as preservative. The samples of the grasses were kept in paper bags after having been dried. All the solid samples were ground in a Willy mill at the end of each experimental period; the powder obtained was mixed, and large enough portions of it were put into amber bottles provided with tight stoppers to be preserved for analysis. All the analyses reported in this study have been performed according to the methods of the Association of Official Agricultural Chemists. In the case of the nitrogen determinations, we used a solution consisting of ten

TABLE A

FIELD CONDITIONS OF THE GRASSES USED IN THE TRIALS PERFORMED

Trial No.	Common name of the grass	Scientific name of the grass	Fertilized with*	Dates on which samples were collected	Cutting	Stage of maturation when cut	Rain in inches
2	Corn fodder	*Zea Mays L.*	N and P.	August 27 to Sept. 5, 1936	1st	In flower	8.37 to 8.92
4	Elephant grass	*Pennisetum purpureum* Schum.	N	Sept. 22 to Oct. 2/36	1st	Just before flowering	8.92 to 6.85
13	Elephant grass	*Pennisetum purpureum* Schum.	N	Jan. 6 to Jan. 16/37	1st	Just before flowering	17.39
6	Elephant grass	*Pennisetum purpureum* Schum.	N and P.	Oct. 13 to Oct. 23/36	1st	Just before flowering	6.85
11	Elephant grass	*Pennisetum purpureum* Schum.	N	Dec. 16 to Dec. 26/36	1st	Just before flowering	8.61
5	Guinea grass	*Panicum maximum* Jacq.	N	Oct. 13 to Oct. 23/36	1st	In flower	6.85
12	Guinea grass	*Panicum maximum* Jacq.	N	Dec. 16 to Dec. 26/36	1st	In flower	8.61
7	Guinea grass	*Panicum maximum* Jacq.	N and P.	Nov. 4 to Nov. 14/36	1st	In flower	2.38
14	Guinea grass	*Panicum maximum* Jacq.	N and P.	Jan. 6 to Jan. 16/37	1st	In flower	17.39
8	Malojillo or Para grass	*Panicum barbinode* Trin.	N	Nov. 4 to Nov. 14/36	1st	Just before flowering	2.38
27	Malojillo or Para grass	*Panicum barbinode* Trin.	N	April 28 to May 8/37	2nd	In flower	1.54
20	Malojillo or Para grass	*Panicum barbinode* Trin.	N and P.	March 15 to 25/37	2nd	In flower	0.45
25	Malojillo or Para grass	*Panicum barbinode* Trin.	N and P.	April 17 to 27/37	2nd	In flower	1.54
9	Guatemala grass	*Tripsacum laxum* Nash.	N	Nov. 25 to Dec. 5/36	1st	Just before flowering	2.38
23	Guatemala grass	*Tripsacum laxum* Nash.	N	March 26 to April 5/37	2nd	Just before flowering	0.47 to 1.54
10	Guatemala grass	*Tripsacum laxum* Nash.	N and P.	Nov. 25 to Dec. 5/36	1st	Just before flowering	2.38 to 8.61
22	Guatemala grass	*Tripsacum laxum* Nash.	N and P.	March 26 to April 5/37	2nd	Just before flowering	0.47 to 1.54
24	Yaragua or molasses grass	*Melinis minutiflora* Beuv.	N	April 6 to April 16/37	2nd	Just before flowering	1.54
17	Yaragua or molasses grass	*Melinis minutiflora* Beuv.	N and P.	Feb. 20 to March 2/37	2nd	Just before flowering	1.08 to 0.47
26	Yaragua or molasses grass	*Melinis minutiflora* Beuv.	N and P.	April 17 to April 27/37	2nd	Just before flowering	1.54

*N means those fertilized with ammonium sulphate alone. N and P means those fertilized with ammonium sulphate and superphosphate.

parts of a saturated solution of methyl red in 50 per cent alcohol and one part of a 0.25 per cent methylene blue solution in water as an indicator to titrate the standard acid in which the ammonia was collected against the standard base. A freshly prepared solution was used whenever titrations were performed. This indicator mixture has the advantage of giving a very sharp end point, changing from violet on the acid side to green on the alkaline side.

An artificial ration having the following composition was given to the animals during the trials performed for determining the minimum protein required for maintenance:

Para grass straw (no leaves)	10.00 per cent
Sugar	21.43 per cent
Starch	21.43 per cent
Cellu flour	43.90 per cent
Bone meal	2.00 per cent
Oil	1.24 per cent

Group A and Group B of our animals became used in this diet after a short time and ate an average of about 400 grams of it per day. The animals of Group D and Group E never became used to it, preferring rather to starve. Due to this, we ran only four trials on this low protein diet; three with animals in Group A and one with animals in Group B. We have calculated the body nitrogen in the feces per gram of dry matter ingested and the body nitrogen in the urine per kilogram of body weight from the data obtained from these trials. The average value obtained from these four trials was applied to all our animals.

Existing data indicates that the body nitrogen in the feces per gram of the dry matter ingested and the body nitrogen in the urine per kilogram of the body weight for sheep receiving a low nitrogen ration is quite uniform. We include the results obtained by other investigators as well as by ourselves for the low protein trials, in table 3. These results are quite close if we consider the different breeds of animals used.

Results

Table no. 1 records the percentage content of nitrogen in the feed consumed, the refuse left, and the feces and urine eliminated. These values are later used in the determination of the biological values of the grasses.

Table no. 2 gives the data gathered during the four ten-day metabolism experiments in which the nearly nitrogen-free rations were fed. The average values obtained for the body nitrogen in

the feces per gram of dry matter ingested and the body nitrogen in the urine per kilogram of body weight are 0.043 grams and 0.526 grams of nitrogen respectively. We have applied these average values in computing all our calculations for the biological values of the proteins.

Table 3 reports the values for body nitrogen in the feces per gram of dry matter ingested and body nitrogen in the urine per kilogram of body weight obtained by other investigators as well as by us.

Table 4 gives a summary of the metabolism experiments upon which the determinations of the biological values of the protein in the grasses are based. "Body Nitrogen Feces" is obtained by multiplying the weight of the total dry feed intake by the body nitrogen in feces per gram of dry matter ingested; while the "Body Nitrogen in Urine" is obtained by multiplying the average body weight of the animal in kilograms by the body nitrogen in urine per kilogram of body weight. The percentage of the total protein absorbed through the intestine and retained in the body is called the "Biological Value" of the protein. This value is computed from the following equation:

$$\text{Biological value} = \frac{100\ \text{Food N} - (\text{Total N in feces} - \text{Body N in feces}) - (\text{Total N in urine} - \text{Body N in urin}}{\text{Food N} - (\text{Total N in feces-Body N in feces})}$$

$$100\ \frac{\text{Food N retained}}{\text{Food N absorbed}}$$

Table 5 contains all the proximate analyses of the offered and refused portions of the rations used in the different experiments. These analyses are all reported on a dry basis. Protein throughout this work is understood to be the nitrogen value multiplied by the factor 6.25.

Table 6 gives the proximate analyses of the feces eliminated during the different trials. These analyses are also given on a dry basis.

The coefficients of apparent digestibilty are given in table 7. By this coefficient we mean the percentage of the substances in the feed eaten that is absorbed in the intestinal tract. Coefficients of apparent digestibility of dry matter, fat, carbohydrate, ash and organic matter have been calculated. These coefficients are computed with the following equation:

$$\text{Coefficient of apparent digestibility} = \frac{100\ \text{Substance in the feed fed} - \text{Substance in the feces eliminated}}{\text{Substance in the feed fed}}$$

Table 8 gives the digestible nutrient in 100 pounds of feedstuff on the wet basis in addition to the nutritive ratio of each ration (5). The digestible fats, carbohydrates and proteins are obtained by multiplying the total amount of each nutrient in 100 pounds of the feed by the apparent coefficient of digestibility for that nutrient, as given in table 7.

The second term of the nutritive ratio is calculated by means of the following formula:

$$\text{The second term of the nutritive ratio} = \frac{(\text{Digestible fat} \times \text{heat equivalent} = 2.25) + \text{Digestible carbohydrates}}{\text{Digestible crude protein}}$$

A feed or ration having much crude protein in proportion to the carbohydrate and fat combined is said to have a narrow nutritive ratio. If the opposite is true it is said to have a wide nutritive ratio.

Table 9 gives the proximate and ash analyses of the grasses investigated, these determinations being reported on the wet basis, while table 10 contains the same data after having been calculated on the dry basis.

Table 11 is a summary of all the coefficients calculated from the data obtained in this investigation.

The vitamin A activity determinations are recorded in table 12.

Discussion

The biological values of the grasses studied do not show great differences if we are to judge these from the results obtained and indicated in the tables.

The proteins of all these grasses seem to be utilized by the lambs with the same efficiency. A significant low result was obtained in Trial No. 6 when elephant grass of the first cutting, fertilized with nitrogen and phosphorus, was fed. The biological value computed for this grass is 69. In the other three trials performed with this grass, much higher results were obtained, viz., 81, 80 and 80; nevertheless, these four samples of elephant grass recorded the lowest biological values obtained in all of the grasses investigated. Two rations of the grass fed to the animals had been fertilized with nitrogen and phosphorus. All of them were from the first cuttings. On the other hand, the malojillo or Para grass has given the highest biological value, viz., 88, 97, 89 and 91. The first value corresponds to a grass from a first cutting fertilized with nitrogen only; the other three were grasses from the second cuttings, one fertilized with nitrogen only and the other two with nitrogen and phosphorus.

The other four grasses investigated gave values which fall within the range of those obtained for elephant and Para grasses.

The data obtained in these experiments seem to indicate that the biological value is not greatly influenced by the addition of phosphorus as fertilizer or by the cutting. We can conclude, on the basis of the results obtained, that the quality of the protein is inherent in the type of grass, since very similar results were obtained for the same grass in first or second cuttings, and when fertilized with nitrogen or nitrogen and phosphorus.

The trials in which Guatemala grass was fed yielded the highest values obtained for the average coefficients of apparent digestibility for the dry matter, the lowest values obtained corresponded to the Yaragua grass. In the case of the coefficients for crude protein, Para grass trials of first cutting grass recorded the highest value, while the three trials with Yaragua grass yielded the lowest results. The other three trials with Para grass of second cuttings were significantly low, running second to the Yaragua grass trial results. The results obtained with second cutting Para grass seem to indicate that the cuttings exert a significant influence upon the digestibility of the protein. It is interesting to note that all the samples of Yaragua grass tested were from second cuttings and that they contained the least digestible proteins of all the grasses studied. Whether this low index of digestibility is inherent to the grass or is due to the cutting cannot be stated with certainty, since only second cuttings of this grass were tested. This grass also recorded very low coefficients of apparent digestibility for ash. These low values may be due either to the fact that the mineral constituents are not as readily absorbed as in the case of the other grasses or to a lack of palatability of the Yaragua grass, which is the least palatable of all the grasses investigated. Consequently, the animals consumed less of this grass during the ten-day experimental periods than the average weights eaten during similar trials with the other grasses. The total intake of mineral matter then was not enough to supply the output. This second explanation seems to us to be the most plausible one. Palatability is unquestionably an important factor which also has to be considered, as it may greatly influence the nutritive indexes. It is quite apparent that the addition of phosphorus to the fertilizer does not seem to influence the apparent coefficients of digestibility to any great extent.

The nutritive ratios show wide variations. Yaragua grass gives a very wide nutritive ratio, as is to be expected, for it has a low protein coefficient of apparent digestibility. As a matter of fact,

the nutritive ratio obtained in Trial No. 24 for this grass is extremely wide due to the very low digestibility of the protein. The values for the other two trials with this grass, although wide, are within reasonable limits. The nutritive ratio for corn fodder shows the narrowest value of all. The other grasses give values a little wider than those obtained for fresh green roughage in the United States.

Second cutting grasses recorded nutritive ratios which were always wider than those of the first cutting grasses. This is most probably due to the fact that the second cutting grasses yield, on a wet basis, lower percentages of protein than first cutting grasses. The fat and carbohydrate contents of second cutting grasses are higher than those for the first cutting grasses.

The chemical analyses of the grasses show some interesting facts. The protein contents vary, when the analyses are calculated on the dry basis, from 9.50 per cent for corn fodder, first cutting fertilized with nitrogen and prosphorus, to 2.61 per cent for Yaragua grass, second cutting, fertilized with nitrogen only. All second cutting grasses show lower protein contents than first cutting grasses. The same is true of the fat The nitrogen-free extract, on the contrary, is always greater in second cutting than in first cutting grasses. Guinea grass shows a higher calcium content than the other grasses; Guatemala grass gives the lowest result. Yaragua grass shows the highest per cent of crude fiber. The phosphorus contents of these grasses seem to be quite constant. The addition of phosphorus to the fertilizer has not shown any appreciable effect on the phosphorus contents of the grasses.

No conclusive results can be obtained from these series of experiments. We have considered only the two factors, fertilizer and cutting, in this discussion, but there is still a third which we have not touched on. This factor is the stage of maturity at which the grasses were cut and eaten by the experimental animals. As will be seen from the table of field conditions presented under the heading "Materials and Methods" at the beginning of this paper, some of the grasses sent to us were cut before the flowering stage and others, during the flowering stage. The stage of maturity at which the grasses are cut affects their nutritive values; therefore, this factor has to be studied separately, and will be, in further experiments.

Summary

1. Twenty metabolic experiments with grasses cut at different periods, between August 1936 and May 1937, are reported.

2. The biological values were determined for these grasses; the

highest recorded values belonging to Para grass and the lowest values to elephant grass.

3. The coefficients of apparent digestibility for Yaragua and malojillo grasses of second cutting are quite low.

4. All the grasses tend to give wide nutritive ratios, but Yaragua and malojillo, second cutting grasses, give exceptionally wide ones.

5. Yaragua grasses show a higher fiber content than any of the other grasses investigated.

6. Guinea grass yields, on analysis, significantly high values for calcium; Guatemala grass yielding the lowest values for this element in all the grasses studied.

7. First cuttings of grasses usually yield higher percentages of protein than second cuttings. The same is true of the fat. The nitrogen-free extract, on the contrary, is lower in first cutting than in second cutting grasses.

8. The addition of phosphorus to the fertilizer does not seem to influence to any great extent the nutritive indexes of the grasses studied.

9. The vitamin A activity of the leaves of the grasses has been determined.

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TABLE 1

PER CENT NITROGEN IN FEED FED, REFUSE LEFT, FECES & URINE

(FEED, REFUSE AND FECES ANALYSES, PER CENT ON DRY BASIS.)

(URINE ANALYSES, PER CENT BY VOLUME.)

Trial No.	Ration	Nitrogen in Feed Fed %	Nitrogen in Refuse Left %	Animal	Nitrogen in Feces %	Nitrogen in Urine %
1.......	Low protein diet Formula I..	0.17	....	1A.... 2A.... 3A....	0.69 0.99 0.91	0.14 0.18 0.20
2.......	Corn fodder (N and P) first.	1.52	1.30	1A.... 2A.... 3A....	1.51 1.47 1.38	0.24 0.30 0.28
3.......	Low protein diet Formula I..	0.23	....	1B.... 2B.... 3B....	0.84 0.92 1.05	0.60 0.37 0.17
4.......	Elephant grass (N only) first.	0.81	0.34	1A.... 2A.... 3A....	1.06 1.07 1.03	0.26 0.34 0.23
13......	Elephant grass (N only) first..	0.87	0.40	1B....	1.01	0.18
6.......	Elephant grass (N and P)... first	0.72	0.37	1A.... 2A.... 3A....	1.09 1.17 1.07	0.28 0.43 0.32
11......	Elephant grass (N and P)... first	1.20	0.52	1B.... 2B.... 3B....	1.14 1.19 1.08	0.13 0.13 0.15
5.......	Guinea grass (N only)....... first	0.94	0.62	1B.... 2B.... 3B....	0.95 0.92 0.93	0.35 0.47 0.42
12......	Guinea grass (N only)....... first	0.87	0.40	1A.... 2A.... 3A....	0.97 1.08 1.08	0.23 0.27 0.30
7.......	Guinea grass (N and P)..... first	0.96	0.73	1B.... 2B.... 3B....	0.99 0.99 0.96	0.35 0.36 0.45
14......	Guinea grass (N and P)..... first	0.83	0.46	1A.... 2A.... 3A....	1.01 1.02 0.99	0.18 0.34 0.25
8.......	Malojillo grass (N only)...... first cutting	1.06	0.52	1A.... 2A.... 3A....	1.28 1.37 1.21	0.21 0.29 0.24
27......	Malojillo grass (N only)...... second cutting	0.50	0.38	1A.... 2A.... 3A....	1.02 0.89 0.81	0.48 0.52 0.38
20......	Malojillo grass (N and P).... second cutting	0.62	0.30	1A.... 2A.... 3A....	1.00 1.01 1.05	0.19 0.40 0.37
25......	Malojillo grass (N and P).... second cutting	0.44	0.34	1D.... 3D....	0.87 0.95	0.27 0.51
....	Guatemala grass (N only).... first cutting	0.80	0.54	1B.... 2B.... 3B....	1.12 1.18 1.15	0.22 0.19 0.16
23......	Guatemala grass (N only).... second cutting	0.69	0.55	1E.... 2E.... 3E....	1.00 1.05 1.15	0.19 0.38 0.22
10......	Guatemala grass (N and P).. first cutting	0.83	0.43	1A.... 2A.... 3A....	1.34 1.15 1.24	0.19 0.17 0.16

TABLE 1—Contiuued

PER CENT NITROGEN IN FEED FED, REFUSE LEFT, FECES & URINE

(FEED, REFUSE AND FECES ANALYSES, PER CENT ON DRY BASIS.)

(URINE ANALYSES, PER CENT BY VOLUME.)

Trial No.	Ration	Nitrogen in Feed Fed %	Nitrogen in Refuse Left %	Animal	Nitrogen in Feces %	Nitrogen in Urine %
22......	Guatemala grass (N and P).. second cutting	0.74	0.58	1D.... 3D....	1.14 1.12	0.22 0.21
24......	Yaragua grass (N only)...... second cutting	0.42	0.37	1A.... 2A.... 3A....	1.29 0.95 0.97	0.33 0.23 0.29
17......	Yaragua grass (N and P).... second cutting	0.54	0.32	1A.... 2A.... 3A....	0.98 0.86 0.95	0.12 0.21 0.21
26......	Yaragua grass (N and P).... second cutting	0.49	0.33	1E.... 2E.... 3E....	0.98 1.10 1.16	0.22 0.34 0.24
15A....	Low protein diet............	0.12	....	1A.... 2A.... 3A....	0.62 0.90 0.94	0.10 0.33 0.84
30......	Low protein diet............ Formula I	0.08	....	1A.... 2A.... 3A....	0.92 0.82 0.80	0.11 0.19 0.12

TABLE 2

MAINTENANCE REQUIREMENT OF LAMBS AVERAGING 17.84 KILOGRAMS IN WEIGHT, BODY NITROGEN IN FECES PER GRAM OF DRY MATTER INGESTED AND BODY NITROGEN IN URINE PER 100 GRAMS OF BODY WEIGHT, BASED ON TEN-DAY TRIALS DURING WHICH NEARLY NITROGEN-FREE RATIONS WERE FED.

Trial No.	Animal No.	Average Weight Kg.	Dry Matter Ingested Gm.	Nitrogen in Feed Consumed %	Total Fecal Nitrogen Gm.	Total Urinary Nitrogen Gm.	Total Urinary & Fecal Nitrogen %	Fecal Nitrogen Per Gm. of Dry Matter Ingested	Urinary Nitrogen Per 100 Gm. Body Weight
1.....	1-A... 2-A... 3-A...	18.35 22.30 18.00	4,245 4,225 3,660	0.17 0.17 0.17	13.80 18.15 15.48	12.71 12.40 8.92	26.51 30.55 24.40	0.0033 0.0043 0.0042	0.694 0.556 0.495
15....	1-A... 2-A... 3-A...	17.25 15.85 15.25	3,640 2,830 1,686	0.12 0.12 0.12	11.30 16.71 6.70	7.37 6.35 9.15	18.67 23.06 15.85	0.0048 0.0059 0.0040	0.427 0.400 0.600
30....	1-A... 2-A... 3-A...	20.48 22.70 20.83	2,920 3,180 2,800	0.08 0.08 0.08	11.98 16.08 10.15	9.90 3.62 4.75	21.88 19.70 14.90	0.0041 0.0051 0.0036	0.483 0.159 0.228
3.....	1-B... 2-B... 3-B...	11.77 16.55 14.78	2,427 3,089 3,401	0.23 0.23 0.23	9.25 14.22 15.65	9.76 10.38 8.35	19.01 24.60 24.00	0.0038 0.0046 0.0046	0.830 0.626 0.565

TABLE 3

VALUES FOR BODY NITROGEN IN FECES PER GRAM OF DRY MATTER INGESTED AND BODY NITROGEN IN URINE PER KILOGRAM OF BODY WEIGHT AS OBTAINED BY DIFFERENT INVESTIGATORS WHEN NEARLY NITROGEN-FREE RATIONS ARE FED TO LAMBS

Remarks	Lamb No.	Body Nitrogen in Feces Per Gram of Dry Matter Ingested	Average Body Nitrogen in Feces Per Gram of Dry Matter Ingested	Body Nitrogen in Urine Per Kilogram of Body Weight	Average Body Nitrogen in Urine Per Kilogram of Body Weight
	1	0.0075	....	0.428	....
Sotola (2) performed two trials on each one of six lambs. Values given are average of the two trials (Black face lambs)	2	0.0068	....	0.236	....
	3	0.0059	....	0.306	....
	4	0.0064	....	0.330	....
	5	0.0070	....	0.350	....
	6	0.0058	0.0066	0.337	0.331
Turk Morrison & Maynard (6). These investigators used five animals and performed two trials on each animal. Values given are average of the two trials. (Young growing wether lambs)	1	0.0061	....	0.556	....
	2	0.0044	....	0.480	....
	3	0.0062	....	0.360	....
	4	0.0065	....	0.552	....
	5	0.0046	0.0056	0.393	0.468
Miller, Morrison and Maynard (7) report the following values obtained in 14 comparable experiments at the Cornell Station (Pure-bred and high-grade wether lambs of excellent mutton type used)	....	0.0055	0.0055	0.370	0.370
The results obtained at the School of Tropical Medicine using six animals are given. Three trials were run on three of these animals and only one trial on the other three. The three trials in group A were run with a lapse of about five months between each trial; the average value obtained for the three trials is given. For animals of group B, the values obtained from the only trial run is given	1A	0.0041	....	0.801	....
	2A	0.0051	....	0.335	....
	3A	0.0036	....	0.441	....
	1B	0.0038	....	0.830	....
	2B	0.0046	....	0.626	....
	3B	0.0046	0.0043	0.565	0.526
(Wild Puerto Rican lambs ranging from six to eighteen months of age)					

TABLE 4

SUMMARY OF METABOLISM EXPERIMENTS UPON WHICH THE DETERMINATIONS OF BIOLOGICAL VALUES OF PROTEINS IN THE GRASSES IS BASED

Trial Number and Ration	Animal No.	Body Weight Initial Kg.	Body Weight Final Kg.	Body Weight Ave. Kg.	Feed Intake Wet Gm.	Feed Intake Dry Gm.	N Intake Gm.	Total Fecal N Gm.	Body N in Feces Gm.	Food N in Feces Gm.	Absorbed N Gm.	Total N in Urine Gm.	Body N in Urine Gm.	Food N in Urine Gm.	Food N Retained Gm.	Biological Value	Ave. Biological Value
Trial 1 Low Protein Diet	1-A...	19.10	17.70	18.35	4,280	4,245	7.22	13.80	13.80	....	....	12.71	12.71	....	....	....	....
	2-A...	23.20	22.00	22.30	4,260	4,225	7.16	18.15	18.15	....	....	12.40	12.40	....	....	....	....
	3-A...	18.50	17.50	18.00	3,690	3,660	6.23	15.48	15.48	....	....	8.92	8.92	....	....	....	....
Trial 2 Corn Fodder (N and P)	1-A...	17.80	21.20	19.50	25,385	5,915	98.30	35.00	25.41	9.59	88.71	22.10	10.25	11.85	76.86	87	
	2-A...	21.60	23.40	22.50	24,791	5,811	97.20	32.80	25.00	7.80	89.40	22.55	11.82	10.73	78.67	88	86
	3-A...	16.55	18.40	17.48	20,305	4,659	81.60	27.00	20.02	6.98	74.62	22.41	9.20	13.11	61.51	83	
Trial 3 Low Protein Diet	1-B...	12.08	11.45	11.77	2,561	2,427	5.61	9.25	9.25	....	....	9.76	9.76	....	....	....	....
	2-B...	16.90	16.20	16.55	3,259	3,089	7.16	14.22	14.22	....	....	10.38	10.38	....	....	....	....
	3-B...	15.05	14.50	14.78	3,588	3,401	7.85	15.65	15.65	....	....	8.35	8.35	....	....	....	....
Trial 4 Elephant Grass (N only)	1-A...	20.85	22.10	21.48	22,230	5,820	71.60	27.20	25.02	2.18	69.42	24.95	11.30	13.65	55.77	80	
	2-A...	23.40	24.20	23.80	20,557	5,367	67.60	24.50	23.10	1.40	66.20	26.90	12.74	14.16	52.04	79	80
	3-A...	17.90	19.50	18.70	19,552	5,052	67.20	24.78	21.80	2.98	64.22	22.20	9.85	12.35	51.87	81	
Trial 13 Elephant grass (N only)	1-B...	14.00	12.50	13.30	28,224	7,050	75.00	28.00	30.30	....	75.00	21.60	7.00	14.60	60.40	81	81
Trial 6 Elephant grass (N and P)	1-A...	21.58	22.39	21.99	20,781	5,500	60.80	30.90	24.00	6.90	53.90	29.00	11.55	17.45	36.45	68	
	2-A...	23.23	23.70	23.47	19,391	5,150	59.20	31.20	22.18	9.02	50.18	29.10	12.35	16.75	33.43	67	69
	3-A...	20.25	19.30	19.78	21,393	5,810	61.60	31.95	25.00	6.95	54.65	25.12	10.40	14.72	39.93	73	
Trial 11 Elephant grass (N and P)	1-B...	14.30	14.30	14.30	31,660	6,432	88.80	28.60	27.61	0.99	87.81	21.80	7.55	14.25	73.56	84	
	2-B...	20.40	20.70	20.55	35,107	6,850	89.10	39.70	29.40	10.30	78.80	27.24	10.80	16.44	62.36	79	80
	3-B...	16.10	16.55	16.33	33,878	6,648	87.95	31.50	28.60	3.90	84.05	27.60	8.60	19.00	65.05	77	
Trial 5 Guinea grass (N only)	1-B...	12.49	13.90	13.20	19,635	5,990	71.10	29.60	25.79	3.81	67.29	16.55	6.95	9.60	57.69	86	
	2-B...	18.10	20.20	19.15	21,785	6,590	74.50	28.90	28.30	0.60	73.90	27.50	10.09	17.41	56.49	77	80
	3-B...	16.55	15.33	15.99	20,108	6,110	71.70	27.95	26.21	1.74	69.96	24.80	8.43	16.37	53.59	77	
Trial 12 Guinea grass (N only)	1-A...	23.80	24.20	24.00	27,903	8,050	89.50	34.80	34.60	0.20	89.30	28.39	12.60	15.79	73.51	82	
	2-A...	23.40	28.10	25.25	26,960	8,170	90.00	43.90	35.10	8.80	81.20	21.50	13.30	8.20	73.00	90	86
	3-A...	19.40	21.5	20.45	26,078	7,820	74.70	31.00	33.60	3.40	71.30	21.50	10.74	10.76	60.54	85	
Trial 7 Guinea grass (N and P)	1-B...	13.40	14.21	13.81	21,680	6,570	75.00	31.00	28.21	2.79	72.21	23.80	7.27	16.53	55.68	77	
	2-B...	18.95	20.00	19.48	22,293	6,750	76.40	28.22	29.00	.....	76.40	29.60	10.23	16.67	59.73	78	77
	3-B...	16.35	15.90	16.13	19,554	5,960	65.50	28.00	25.60	2.40	63.10	23.75	8.50	15.25	47.85	76	

Trial 14	1-A...	23.50	23.70	23.60	27,264	8,180	83.30	37.40	35.35	2.05	81.25	21.35	12.50	8.85	72.40	89	....
Guinea grass.......	2-A...	23.60	23.30	23.45	27,986	8,390	84.28	40.60	36.05	4.55	79.73	21.60	12.30	9.30	70.43	88	89
(N and P)	3-A...	20.00	20.09	20.05	24,761	7,430	79.90	36.00	32.00	4.00	75.90	17.55	10.57	6.98	68.92	91	....
Trial 8	1-A...	21.60	23.18	22.39	26,102	6,260	90.20	32.80	26.90	5.90	84.30	25.35	11.75	13.60	70.70	84	....
Malojillo grass	2-A...	23.95	23.80	23.88	25,183	5,990	88.80	30.00	25.75	4.25	84.55	21.00	12.50	8.50	76.05	90	88
(N only)	3-A...	18.85	21.20	20.03	26,480	6,380	90.80	28.22	27.41	0.81	89.99	18.75	10.56	8.19	81.80	91	....
Trial 27	1-A...	20.80	21.20	21.00	19,104	8,550	51.20	30.90	36.80	....	51.20	9.66	11.07	....	....	....	....
Malojillo grass	2-A...	20.50	20.80	20.65	21,034	9,160	53.55	30.20	39.40	....	53.55	12.40	10.88	1.52	52.03	97	97
(N only)	3-A...	19.10	19.40	19.25	19,968	8,820	52.20	28.95	38.20	....	52.20	8.76	10.10	....	....	....	....
Trial 20	1-A...	21.20	23.40	22.30	26,231	7,240	59.75	36.16	31.10	5.06	54.69	18.40	11.72	6.68	48.01	88	....
Malojillo grass	2-A...	20.70	21.70	21.20	26,216	7,240	59.75	38.02	31.10	6.92	52.83	19.30	11.17	8.13	44.70	85	89
(N and P)	3-A...	18.50	20.40	19.45	23,696	6,430	57.30	33.18	27.61	5.57	51.73	12.78	10.22	2.56	49.17	95	....
Trial 25 Malojillo grass	1-D...	20.20	21.20	20.70	19,923	6,500	34.30	28.75	28.00	0.75	33.55	14.40	10.90	3.50	30.05	91	....
(N and P)	3-D...	13.01	14.85	13.93	15,757	4,780	28.50	23.50	20.59	2.91	25.59	9.57	7.35	2.22	23.37	91	91
Trial 9	1-B...	14.28	17.00	15.64	26,971	7,120	67.00	26.20	30.60	....	67.00	21.50	8.25	13.25	53.75	80	....
Guatemala grass	2-B...	20.50	21.50	21.00	29,073	7,740	70.40	29.99	33.25	....	70.40	21.80	11.08	10.72	59.68	85	84
(N only)	3-B...	17.00	16.30	16.65	28,026	7,450	68.00	26.55	32.00	....	68.00	17.70	8.76	8.94	59.06	87	....
Trial 23	1-E...	14.43	16.05	15.24	19,370	6,720	48.80	23.22	28.85	....	48.80	17.90	8.02	9.88	38.92	80	....
Guatemala grass	2-E...	12.68	14.85	13.77	14,273	4,130	40.00	16.95	17.75	....	40.00	14.90	7.25	7.65	32.35	81	81
(N only)	3-E...	12.42	14.84	13.63	13,814	4,000	39.50	18.71	17.20	....	39.50	14.70	7.19	7.51	31.99	81	....
Trial 10	1-A...	22.80	22.70	22.75	26,969	6,380	67.42	31.80	27.41	4.39	63.03	23.15	11.96	11.19	51.84	82	....
Guatemala grass	2-A...	24.80	23.60	24.20	28,285	6,755	69.00	28.50	29.00	....	69.00	22.50	11.83	10.67	58.33	85	85
(N and P)	3-A...	18.95	20.60	19.78	28,690	6,860	69.50	31.40	29.50	1.90	67.60	19.10	10.40	8.70	58.90	87	....
Trial 22 Guatemala grass	1-D...	18.70	21.20	19.95	23,023	7,100	61.20	25.40	30.50	....	61.20	21.92	10.50	11.42	49.78	81	....
(N and P)	3-D...	12.81	12.88	12.88	15,019	4,730	47.50	20.00	20.03	....	47.50	11.61	6.77	4.84	42.66	90	86
Trial 24	1-A...	21.00	18.27	19.64	16,325	4,660	24.40	29.00	20.00	9.00	15.40	14.30	10.33	3.97	11.43	75	....
Yaragua grass	2-A...	21.02	20.55	20.79	19,754	6,100	29.97	28.00	26.20	1.80	28.17	12.00	10.90	1.10	27.07	96	88
(N only)	3-A...	18.87	19.80	19.34	19,323	5,900	29.10	31.50	25.40	6.10	23.00	12.00	10.19	1.81	21.19	92	....
Trial 17	1-A...	20.85	21.95	20.98	16,932	4,930	35.10	27.50	21.20	6.30	28.80	12.70	11.00	1.70	27.10	94	....
Yaragua grass	2-A...	18.60	22.25	20.43	18,636	5,655	36.61	27.15	24.35	2.80	33.81	14.40	10.79	3.61	30.20	89	90
(N and P)	3-A...	18.50	18.50	18.50	16,106	4,580	33.30	26.50	19.70	6.80	26.50	13.35	9.75	3.60	22.90	87	....
Trial 26	1-E...	15.25	14.70	14.98	15,776	4,670	34.20	25.58	20.10	5.48	28.72	15.30	7.98	7.32	21.40	75	85
Yaragua grass	2-E...	14.44	14.70	14.75	11,657	3,110	18.20	20.50	13.35	7.15	21.05	9.50	7.77	1.73	19.32	92	85
(N and P)	3-E...	14.03	14.30	14.17	13,790	4,000	31.10	27.10	17.20	9.90	21.20	10.10	7.45	2.65	18.55	88	....
Trial 15-A...........	1-A...	17.90	16.60	17.25	4,000	3,640	4.37	11.29	11.29	....	....	7.37	7.37	....	....	....	....
Low Protein	2-A...	16.60	15.10	15.85	3,106	2,830	3.40	16.72	16.72	....	....	6.35	6.35	....	....	....	....
Diet	3-A...	15.40	15.10	15.25	1,855	1,686	2.02	6.76	6.76	....	....	9.15	9.15	....	....	....	....
Trial 30	1-A...	21.30	19.65	20.48	3,183	2,920	2.34	11.91	11.91	....	....	9.90	9.90	....	....	....	....
Low Protein	2-A...	24.20	21.20	22.70	3,463	3,180	2.55	16.10	16.10	....	....	3.62	3.62	....	....	....	....
Diet	3-A...	21.40	20.25	20.83	3,072	2,800	2.24	10.20	10.20	....	....	4.75	4.75	....	....	....	....

TABLE 5

PROXIMATE ANALYSES, REPORTED ON DRY BASIS, OF THE FED AND REFUSED PORTIONS OF THE RATIONS USED IN THE DIFFERENT METABOLISM EXPERIMENTS

Ration	Crude Protein (N x 6.25) %		Fat %		Crude Fiber %		Nitrogen-free Extract %		Ash %	
	Feed fed	Feed refused	Feed fed	Feed refused	Feed fed	Feed refused	Feed fed	Feed refused	Feed fed	Feed refused
TRIAL No. 2: Corn fodder (fert. N and P) first cutting	9.59	8.12	4.31	2.87	30.90	27.20	49.30	55.83	5.99	5.98
TRIAL No. 4: Elephant grass (fert. N only) first cutting	5.06	2.12	3.60	2.28	36.35	41.45	47.63	49.45	7.36	4.70
TRIAL No. 13: Elephant grass (fert. N only) first cutting	5.44	2.50	2.61	2.12	37.25	39.60	44.10	46.92	10.60	8.86
TRIAL No. 6: Elephant grass (fert. N and P) first cutting	4.50	2.31	2.96	1.96	35.80	43.70	49.84	47.78	6.90	4.25
TRIAL No. 11: Elephant grass (fert. N and P) first cutting	7.50	3.26	3.24	2.53	32.88	37.00	45.98	48.16	10.40	9.05
TRIAL No. 5: Guinea grass (fert. N only) first cutting	5.87	3.88	2.76	1.69	38.20	39.40	43.52	46.15	9.65	8.88
TRIAL No. 12: Guinea grass (fert. N only) first cutting	5.44	2.50	2.14	1.48	34.05	39.75	46.57	46.92	11.80	9.35
TRIAL No. 7: Guinea grass (fert. N and P) first cutting	6.00	4.56	2.43	1.74	35.43	38.25	46.56	46.51	9.58	8.94
TRIAL No. 14: Guinea grass (fert. N and P) first cutting	5.18	2.78	2.60	1.86	33.80	35.93	46.27	46.25	12.15	13.18
TRIAL No. 8: Malojillo grass (fert. N only) first cutting	6.64	3.25	2.52	1.42	31.00	36.05	50.77	51.92	9.07	7.36
TRIAL No. 27: Malojillo grass (fert. N only) second cutting	3.11	2.39	1.79	1.32	33.05	32.90	56.35	58.85	5.70	4.54
TRIAL No. 20: Malojillo grass (fert. N and P) second cutting	3.88	1.88	1.97	1.43	32.50	34.88	53.39	55.62	8.26	6.19

TRIAL No. 25: Malojillo grass (fert. N and P) second cutting	2.75	2.12	1.74	1.61	32.50	35.95	55.79	54.06	7.22	6.26
TRIAL No. 9: Guatemala grass (fert. N only) first cutting	5.00	3.38	2.98	1.72	37.03	42.21	47.54	45.82	7.45	6.87
TRIAL No. 23: Guatemala grass (fert. N only) second cutting	4.31	3.44	2.47	1.75	33.40	34.96	51.79	52.72	8.03	7.13
TRIAL No. 10: Guatemala grass (fert. N and P) first cutting	5.19	2.69	2.89	1.97	35.55	38.15	47.71	48.67	8.66	8.52
TRIAL No. 22: Guatemala grass (fert. N and P) second cutting	4.62	3.65	2.68	2.32	31.25	35.25	53.20	50.90	8.25	7.88
TRIAL No. 24: Yaragua grass (fert. N only) second cutting	2.61	2.30	2.23	2.14	38.60	40.20	49.12	48.41	7.44	6.95
TRIAL No. 17: Yaragua grass (fert. N and P) second cutting	3.40	1.97	2.10	1.33	42.15	48.10	44.60	43.26	7.45	5.34
TRIAL No. 26: Yaragua grass (fert. N and P) second cutting	3.06	2.06	2.63	1.92	39.90	42.90	48.21	47.42	6.20	5.70

TABLE 6

PROXIMATE ANALYSES OF THE FECES, REPORTED ON DRY BASIS, AVERAGE COMPOSITE SAMPLE OF TEN-DAY METABOLISM EXPERIMENTS

Trial No.	Animal No.	Ration	Crude Protein (N x 6.25) %	Fat %	Crude Fiber %	Nitrogen-free Extract %	Ash %
1.......	1-A...	Low protein diet form I........	4.30	....	....	....	....
	2-A...	Low protein diet form I........	6.18	....	....	....	....
	3-A...	Low protein diet form I........	5.68	....	....	....	....
2.......	1-A...	Corn fodder (fert. N and P) firts cutting..................	9.44	2.53	23.55	52.78	11.70
	2-A...	Corn fodder (fert. N and P) first cutting..................	9.19	2.31	24.34	53.35	10.81
	3-A...	Corn fodder (fert. N and P) first cutting..................	8.60	2.69	24.45	51.68	12.58
3.......	1-B...	Low protein diet form I........	5.25	....	....	....	....
	2-B...	Low protein diet form I........	5.75	....	....	....	....
	3-B...	Low protein diet form I........	6.55	....	....	....	....
4.......	1-A...	Elephant grass (fert. N only) first cutting..................	6.67	3.06	24.80	50.02	15.45
	2-A...	Elephant grass (fert. N only) first cutting..................	6.67	3.04	27.55	46.93	15.81
	3-A...	Elephant grass (fert. N only) first cutting..................	6.44	3.06	30.00	46.30	14.20
13......	1-B...	Elephant grass (fert. N only) first cutting..................	6.30	2.79	29.90	45.11	15.90
6.......	1-A...	Elephant grass (fert. N and P) first cutting..................	6.81	3.23	31.37	42.86	15.73
	2-A...	Elephant grass (fert. N and P) first cutting..................	7.30	3.37	26.35	47.40	15.58
	3-A...	Elephant grass (fert. N and P) first cutting..................	6.68	3.18	29.90	46.17	14.07
11......	1-B...	Elephant grass (first N and P) first cutting..................	7.14	2.62	29.10	45.34	15.80
	2-B...	Elephant grass (fert. N and P) first cutting..................	7.45	3.04	30.50	43.20	15.81
	3-B...	Elephant grass (fert. N and P) first cutting..................	6.75	2.76	31.51	43.28	15.70
5.......	1-B...	Guinea grass (fert. N only) first cutting..................	5.94	2.48	32.14	43.63	15.81
	2-B...	Guinea grass (fert. N only) first cutting..................	5.75	2.39	32.28	43.78	15.80
	3-B...	Guinea grass (fert. N only) first cutting..................	5.81	2.26	32.97	42.31	16.65
12......	1-A...	Guinea grass (fert. N only) first cutting..................	6.06	3.04	31.05	40.15	19.70
	2-A...	Guinea grass (fert. N only) first cutting..................	6.75	2.89	29.04	39.92	21.40
	3-A...	Guinea grass (fert. N only) first cutting..................	6.75	2.74	26.09	43.42	21.00
7.......	1-B...	Guinea grass (fert. N and P) first cutting..................	6.19	2.94	32.86	42.10	15.91
	2-B...	Guinea grass (fert. N and P) first cutting..................	6.19	2.81	33.15	41.40	16.45
	3-B...	Guinea grass (fert. N and P) first cutting..................	6.00	2.93	30.40	43.47	17.20
14......	1-A...	Guinea grass (fert. N and P) first cutting..................	6.30	2.56	28.47	41.29	21.38
	2-A...	Guinea grass (fert. N and P) first cutting..................	6.37	2.34	28.55	40.33	22.41
	3-A...	Guinea grass (fert. N and P) first cutting..................	6.19	2.36	27.20	42.45	21.80
8.......	1-A...	Malojillo grass (fert. N only) first cutting..................	8.00	3.57	28.35	44.48	15.60
	2-A...	Malojillo grass (fert. N only) first cutting..................	8.55	3.55	22.50	47.90	17.50
	3-A...	Malojillo grass (fert. N only) first cutting..................	7.56	3.10	26.70	48.24	14.40

TABLE 6—Continued

PROXIMATE ANALYSES OF THE FECES, REPORTED ON DRY BASIS, AVERAGE COMPOSITE SAMPLE OF TEN-DAY METABOLISM EXPERIMENTS

Trial No.	Animal No.	Ration	Crude Protein (N x 6.25) %	Fat %	Crude Fiber %	Nitrogen-free Extract %	Ash %
27......	1-A...	Malojillo grass (fert. N only) second cutting...............	6.38	1.69	33.50	48.13	10.30
	2-A...	Malojillo grass (fert. N only) second cutting...............	5.56	1.89	31.85	50.08	10.62
	3-A...	Malojillo grass (fert. N only) second cutting...............	5.06	1.72	33.85	48.47	10.90
20......	1-A...	Malojillo grass (fert. N and P) second cutting...............	6.25	1.92	30.66	46.57	14.60
	2-A...	Malojillo grass (fert. N and P) second cutting...............	6.31	1.22	32.70	46.27	13.50
	3-A...	Malojillo grass (fert. N and P) second cutting...............	6.56	1.36	30.10	47.13	14.85
25......	1-D...	Malojillo grass (fert. N and P) second cutting...............	5.45	1.90	35.35	43.80	13.50
	3-D...	Malojillo grass (fert. N and P) second cutting...............	5.94	1.82	35.30	44.04	12.90
9.......	1-B...	Guatemala grass (fert. N only) first cutting..................	7.00	2.46	31.35	47.24	11.95
	2-B...	Guatemala grass (fert. N only) first cutting..................	7.37	2.28	32.08	45.58	12.70
	3-B...	Guatemala grass (fert. N only) first cutting..................	7.19	2.31	30.23	47.87	12.40
28......	1-E...	Guatemala grass (fert. N only) second cutting...............	6.25	2.07	30.12	47.96	13.60
	2-E...	Guatemala grass (fert. N only) second cutting...............	6.56	2.24	31.21	45.69	14.30
	3-E...	Guatemala grass (fert. N only) second cutting...............	7.20	2.30	30.05	45.20	15.25
10......	1-A...	Guatemala grass (fert. N and P) first cutting..................	8.38	2.49	32.30	43.53	13.30
	2-A...	Guatemala grass (fert. N and P) first cutting..................	7.19	2.34	30.95	45.92	13.60
	3-A...	Guatemala grass (fert. N and P) first cutting..................	7.75	2.35	31.81	45.09	13.00
22......	1-D...	Guatemala grass (fert. N and P) second cutting...............	7.13	2.19	30.45	45.63	14.60
	3-D...	Guatemala grass (fert. N and P) second cutting...............	7.00	2.32	29.35	46.13	15.20
24......	1-A...	Yaragua grass (fert. N only) second cutting...............	8.05	2.99	28.73	44.58	15.65
	2-A...	Yaragua grass (fert. N only) second cutting...............	5.94	2.88	30.60	46.18	14.40
	3-A...	Yaragua grass (fert. N only) second cutting...............	6.05	3.22	30.90	45.33	14.50
17......	1A....	Yaragua grass (fert. N and P). second cutting...............	6.13	2.56	29.20	45.81	16.30
	2-A...	Yaragua grass (fert. Nand P) second cutting...............	5.37	2.19	31.45	46.29	14.70
	3-A...	Yaragua grass (fert. N and P) second cutting...............	5.94	2.98	29.09	45.89	16.10
26......	1-E...	Yaragua grass (fert. N and P) second cutting...............	6.13	3.93	30.50	44.64	14.80
	2-E...	Yaragua grass (fert. N and P) second cutting...............	6.87	3.92	31.00	44.81	13.40
	3-E...	Yaragua grass (fert. N and P) second cutting...............	7.25	4.10	29.25	45.19	14.21
15-A...	1-A...	Low protein diet form I........	3.88	....	....	....	....
	2-A...	Low protein diet form I........	5.62	....	....	....	....
	3-A...	Low protein diet form I........	5.87	....	....	....	....
30......	1-A...	Low protein diet form II.......	5.75	....	....	....	....
	2-A...	Low protein diet form II.......	5.11	....	....	....	....
	3-A...	Low protein diet form II.......	4.97	....	....	....	....

TABLE 7

COEFFICIENTS OF APPARENT DIGESTIBILITY

Trial No.	Ration	Animal No.	Dry Matter %	Crude Protein (N x 6.25)%	Fat %	Crude Fiber %	Nitrogen-free Extract %	Ash %	Organic Matter %
2	Corn fodder (N and P) first cutting in flower	1-A	62	66	82	73	56	27	66
		2-A	63	67	84	73	56	33	65
		3-A	59	68	81	71	50	14	62
	AVERAGE		61	67	82	72	54	24	64
4	Elephant grass (N only) first cutting before flowering	1-A	57	63	72	66	53	31	66
		2-A	58	65	74	63	57	33	61
		3-A	53	64	72	54	53	36	54
	AVERAGE		56	64	73	61	54	33	60
13	Elephant grass (N only) first cutting before flowering.	1-B	61	63	61	68	59	45	63
	AVERAGE		61	63	61	68	59	45	63
6	Elephant grass (N and P) first cutting before flowering	1-A	49	49	59	43	58	17	53
		2-A	48	47	58	48	53	20	51
		3-A	49	48	58	46	54	24	51
	AVERAGE		49	48	58	46	54	20	52
11	Elephant grasss (N and P) first cutting before flowering	1-B	61	67	70	65	61	42	64
		2-B	51	56	56	54	54	27	54
		3-B	55	63	63	56	57	33	57
	AVERAGE		56	62	63	58	57	34	58
5	Guinea grass (N only) first cutting in flower	1-B	48	58	64	56	46	19	59
		2-B	52	62	67	59	51	26	55
		3-B	50	60	68	57	50	19	55
	AVERAGE		50	60	66	57	49	21	56
12	Guinea grass (N only) first cutting in flower	1-A	53	59	42	53	60	29	58
		2-A	50	51	41	54	58	18	51
		3-A	56	58	52	63	59	30	60
	AVERAGE		53	56	45	57	59	28	56

7	Guinea grass (N and P) first cutting in flower	1–B	52	59	53	53	57	25	55
		2–B	58	64	60	58	63	31	60
		3–B	51	60	54	55	54	17	55
	AVERAGE		53	61	56	55	58	24	63
14	Guinea grass (N and P) first cutting in flower	1–A	55	55	60	61	60	17	60
		2–A	53	52	62	59	59	9	58
		3–A	51	55	63	59	55	7	57
	AVERAGE		53	54	62	60	58	11	58
8	Malojillo grass (N and P) first cutting before flowering	1–A	59	64	56	58	64	38	67
		2–A	64	66	62	70	65	38	73
		3–A	63	69	65	65	65	49	70
	AVERAGE		62	66	61	64	64	42	71
27	Malojillo grass (N only) second cutting in flower	1–A	65	39	73	65	69	46	66
		2–A	63	43	62	65	66	39	65
		3–A	61	46	68	60	65	35	63
	AVERAGE		63	42	68	63	67	40	65
20	Malojillo grass (N and P) second cutting in flower	1–A	50	39	59	51	55	24	53
		2–A	48	36	73	45	54	31	50
		3–A	51	42	73	52	55	27	54
	AVERAGE		50	39	68	49	55	27	52
25	Malojillo grass (N and P) second cutting in flower	1–D	49	16	57	40	61	16	52
		3–D	48	17	51	....	60	22	50
	AVERAGE		32	17	54	40	61	19	51
9	Guatemala grass (N only) first cutting before flowering	1–B	67	61	78	70	68	50	69
		2–B	67	58	79	70	69	46	69
		3–B	69	61	81	73	70	50	71
	AVERAGE		68	60	79	71	69	49	70
23	Guatemala grass (N only) second cutting before flowering	1–E	59	52	75	62	62	39	58
		2–E	61	58	78	60	64	43	63
		3–E	59	53	77	59	63	38	61
	AVERAGE		60	54	77	60	63	40	61

TABLE 7—Continued

COEFFICIENTS OF APPARENT DIGESTIBILITY

Trial No.	Ration	Animal No.	Dry Matter %	Crude Protein (N x 6.25)%	Fat %	Crude Fiber %	Nitrogen-free Extract %	Ash %	Organic Matter %
10........	Guatemala grass (N & P) first cutting before flowering.	1-A.......	63	53	73	65	66	44	65
		2-A.......	63	59	74	67	64	43	65
		3-A.......	63	55	74	67	65	45	65
	AVERAGE................................	....	63	56	74	66	65	44	65
22........	Guatemala grass (N & P) second cutting before flowering.	1-D.......	69	58	77	66	74	47	71
		3-D.......	62	57	73	54	70	35	65
	AVERAGE................................	....	66	58	75	60	72	41	68
24........	Yaragua grass (N only) second cutting before flowering..	1-A.......	52	....	41	61	57	11	56
		2-A.......	52	5	41	60	56	14	55
		3-A.......	45	....	25	54	51	2	49
	AVERAGE................................	....	50	5	36	58	50	9	53
17........	Yaragua grass (N & P) second cutting before flowering...	1-A.......	43	23	55	56	43	....	48
		2-A.......	44	27	58	55	43	3	48
		3-A.......	39	21	45	52	39	....	44
	AVERAGE................................	....	42	24	53	54	42	3	47
26........	Yaragua grass (N & P) second cutting before flowering..	1-E.......	44	25	41	45	50	....	59
		2-E.......	40	29	49	40	46	....	44
		3-E.......	42	13	38	51	47	....	46
	AVERAGE................................	....	42	22	43	45	48	....	50

TABLE 8

DIGESTIBLE NUTRIENTS IN 100 LBS. OF PUERTO RICAN FEEDING STUFFS AS CUT

Feeding stuff	Total dry matter	Digestible Nutrients				Nutritive ratio
		Crude Protein	Fat	Carbo-hydrates	Total (inc. fat x 2.25)	
1 Corn fodder (fert. N and P) first cutting	23.79	1.51	0.84	11.71	13.60	1:9.0
4 Elephant grass (fert. N only) first cutting	27.68	0.90	0.73	13.06	14.75	1:16.4
18 Elephant grass (fert. N only) first cutting	24.60	0.85	0.39	12.64	13.52	1:16.0
6 Elephant grass (fert. N and P) first cutting	30.08	0.63	0.52	13.05	14.22	1:22.5
11 Elephant grass (fert. N and P) first cutting	19.23	0.90	0.39	8.70	9.58	1:10.6
5 Guinea grass (fert. N only) first cutting	29.44	1.05	0.54	12.20	13.42	1:12.8
12 Guinea grass (fert. N only) first cutting	29.84	0.91	0.29	14.00	14.66	1:16.1
7 Guinea grass (fert. N and P) first cutting	29.64	1.08	0.40	13.81	14.71	1:13.6
14 Guinea grass (fert. N and P) first cutting	30.00	0.84	0.48	14.05	15.13	1:18.0
8 Malojillo grass (fert. N only) first cutting	26.18	1.15	0.40	13.70	14.60	1:12.7
27 Malojillo grass (fert. N only) second cutting	37.90	0.50	0.46	22.33	23.37	1:46.7
20 Malojillo grass (fert. N and P) second cutting	29.10	0.44	0.39	12.27	13.15	1:30.0
25 Malojillo grass (fert. N and P) second cutting	34.00	0.21	0.32	17.57	18.29	1:87.0
9 Guatemala grass (fert. N only) first cutting	27.00	0.81	0.64	15.20	16.64	1:20.6
28 Guatemala grass (fert. N only) second cutting	30.50	0.70	0.57	16.40	17.68	1:25.2
10 Guatemala grass (fert. N and P) first cutting	24.60	0.72	0.53	13.42	14.62	1:20.4
22 Guatemala grass (fert. N and P) second cutting	30.40	0.81	0.62	17.30	18.70	1:23.1
24 Yaragua grass (fert. N only) second cutting	36.30	0.05	0.29	17.08	17.74	1:35.4
17 Yaragua grass (fert. N and P) second cutting	34.00	0.28	0.44	14.13	15.12	1:54.0
26 Yaragua grass (fert. N and P) second cutting	34.80	0.23	0.40	14.30	15.20	1:66.2

Note: "N and P" stands for nitrogen and phosphorus in the fertilizer.
"N" stands for nitrogen only in the fertilizer.

TABLE 9

PROXIMATE ANALYSES OF THE GRASSES USED IN THE NUTRITIONAL EXPERIMENTS AS CUT (WET BASIS)

Trial No.	Dates on which the grasses were collected at Río Piedras	Name of the grass	Total moisture as fed %	Crude protein (N x 6.25)%	Fat %	Crude fiber %	N-free extract %	Ash %	Calcium %	Phosphorus %
2	August 27 to September 5, 1936	Corn fodder (N and P) first cutting in flower	76.21	2.26	1.02	7.35	11.74	1.42	0.0621	0.0415
4	September 22 to October 2, 1936	Elephant grass (N only) first cutting before flowering	72.32	1.40	1.00	10.10	12.78	2.40	0.0582	0.0393
13	January 6 to January 16, 1937	Elephant grass (N only) first cutting before flowering	75.40	1.34	0.64	9.18	10.83	2.61	0.0825	0.0430
6	October 3 to October 23, 1936	Elephant grass (N and P) first cutting before flowering	69.92	1.31	0.89	10.79	15.01	2.08	0.0866	0.0425
11	December 16 to December 26, 1936	Elephant grass (N and P) first cutting before flowering	80.77	1.44	0.62	6.34	8.83	2.00	0.0640	0.0420
5	October 3 to October 23, 1936	Guinea grass (N only) first cutting in flower	70.56	1.73	0.81	11.21	11.85	3.84	0.0983	0.0347
12	December 16 to December 26, 1936	Guinea grass (N only) first cutting in flower	70.16	1.62	0.64	10.18	13.88	3.52	0.1330	0.0630
7	November 4 to November 14, 1936	Guinea grass (N and P) first cutting in flower	70.36	1.78	0.72	10.50	13.80	2.84	0.1050	0.0456
14	January 6 to January 16, 1937	Guinea grass (N and P) first cutting in flower	70.16	1.56	0.78	10.15	13.70	3.65	0.1430	0.0741
8	November 4 to November 14, 1936	Malojillo grass (N only) first cutting before flowering	73.82	1.74	0.66	8.11	13.30	2.37	0.0772	0.0374
27	April 28 to May 8, 1937	Malojillo grass (N only) second cutting in flower	62.10	1.18	0.68	12.50	15.53	2.41	0.0718	0.0383
20	March 15 to March 25, 1937	Malojillo grass (N and P) second cutting in flower	70.90	1.13	0.57	9.46	19.12	2.45	0.0854	0.0500
25	April 17 to April 27, 1937	Malojillo grass (N and P) second cutting in flower	66.00	0.94	0.59	10.90	12.83	2.01	0.0485	0.0335
9	November 25 to December 5, 1936	Guatemala grass (N only) first cutting before flowering	73.00	1.35	0.81	10.00	16.03	2.42	0.0546	0.0450

23......	March 26 to April 5, 1937..........	Guatemala grass (N only) second cutting before flowering	69.50	1.30	0.74	10.01	11.73	2.13	0.0448	0.0335
10......	November 25 to December 5, 1936.....	Guatemala grass (N and P) first cutting before flowering ..	75.40	1.28	0.71	8.75	16.18	2.50	0.0523	0.0441
22......	March 26 to April 5, 1937..........	Guatemala grass (N and P) second cutting before flowering	69.60	1.40	0.82	9.50	16.18	2.50	0.0523	0.0441
24......	April 6 to April 16, 1937..........	Yaragua grass (N only) second cutting before flowering	63.70	0.95	0.81	14.00	17.84	2.70	0.1248	0.0581
17......	February 20 to March 2, 1937..........	Yaragua grass (N and P) second cutting before flowering	66.00	1.16	0.82	14.30	15.20	2.52	0.0950	0.0443
26......	April 17 to April 27, 1937	Yaragua grass (N and P) second cutting before flowering	65.20	1.06	0.92	13.90	16.76	2.16	0.0973	0.0613

TABLE 10

ANALYSES OF THE GRASSES ON DRY BASIS

Name of the Grass	Total Solids %	Crude Protein (N x 6.25) %	Fat %	Crude Fiber %	Nitrogen Free Extract %	Ash %	Ca %	P %	P. Ca %
Corn fodder (N and P) first cutting....................	23.79	9.50	4.31	30.90	49.30	5.99	0.262	0.180	1:1.45
Elephant grass (N only) first cutting..................	27.68	5.06	3.60	36.35	47.63	7.36	0.210	0.142	1:1.48
Elephant grass (N only) first cutting..................	24.60	5.44	2.61	37.25	44.10	10.60	0.335	0.175	1:1.90
Elephant grass (N and P) first cutting................	30.08	4.50	2.96	35.80	49.84	6.90	0.288	0.138	1:2.08
Elephant grass (N and P) first cutting................	19.23	7.50	3.24	32.88	45.98	10.40	0.323	0.218	1:1.48
Guinea grass (N only) first cutting....................	29.44	5.87	2.76	38.20	43.52	9.65	0.334	0.117	1 2.86
Guinea grass (N only) first cutting....................	29.84	5.44	2.14	34.05	46.57	11.80	0.445	0.214	1:2.08
Guinea grass (N and P) first cutting..................	29.64	6.00	2.43	35.43	46.56	9.58	0.346	0.154	1:2.24
Guinea grass (N and P) first cutting..................	30.00	5.18	2.60	33.80	46.27	12.15	0.477	0.247	1:1.93
Malojillo grass (N only) first cutting..................	26.18	6.64	2.52	31.00	50.77	9.07	0.295	0.143	1:2.06
Malojillo grass (N only) second cutting................	37.90	3.11	1.79	33.05	56.35	5.70	0.212	0.108	1:2.05
Malojillo grass (N and P) second cutting..............	29.10	3.88	1.97	32.50	53.39	8.26	0.246	0.132	1:1.86
Malojillo grass (N and P) second cutting..............	34.00	2.75	1.74	32.50	55.79	7.22	0.251	0.147	1:1.70
Guatemala grass (N only) first cutting................	27.00	5.00	2.98	37.03	47.54	7.45	0.180	0.124	1:1.45
Guatemala grass (N only) second cutting..............	30.50	4.31	2.47	33.40	51.79	8.03	0.182	0.147	1:1.24
Guatemala grass (N and P) first cutting..............	24.60	5.19	2.89	35.55	47.71	8.66	0.182	0.136	1:1.34
Guatemala grass (N and P) second cutting............	30.40	4.62	2.68	31.25	53.20	8.25	0.188	0.145	1:1.30
Yaragua grass (N only) second cutting................	36.30	2.61	2.23	38.60	49.12	7.44	0.343	0.160	1:2.14
Yaragua grass (N and P) second cutting..............	34.00	3.40	2.40	42.15	44.60	7.45	0.279	0.130	1:2.14
Yaragua grass (N and P) second cutting..............	34.80	3.06	2.63	39.90	48.21	6.20	0.279	0.176	1:1.59

N and P stand for nitrogen and phosphorus in the fertilizer.
N stand for nitrogen only in the fertilizer.

TABLE 11

SUMMARY OF THE NUTRITIVE INDEXES DETERMINED IN THE EXPERIMENTS PERFORMED DURING THE YEAR OF 1936-37

Ration	Dates on which Samples were collected	Coefficients of apparent digestibility: Dry Matter	Crude Protein	Fat	Crude Fiber	N free Extract	Ash	Organic Matter	Biological Value of Protein	Nutritive Ratio 1 to	P: Ca Ratio 1 to
TRIAL No. 2: Corn fodder fert. N and P first cutting	August 27 to Sept. 5, 1935	61	67	82	72	54	24	64	86	9	1.45
TRIAL No. 4: Elephant grass fert. N only first cutting	September 22 to October 2, 1936	56	64	73	61	54	33	60	80	16.4	1.48
TRIAL No. 13: Elephant grass fert. N only first cutting	January 6 to January 16, 1937	61	63	61	68	59	45	63	81	16.0	1.90
TRIAL No. 6: Elephant grass fert. N and P first cutting	October 13 to October 23, 1936	49	48	58	46	54	20	52	69	22.5	2.08
TRIAL No. 11: Elephant grass fert. N only first cutting	December 16 to Dec. 26, 1935	56	62	63	58	57	34	58	80	10.6	1.48
TRIAL No. 5: Guinea grass fert. N only first cutting	October 13 to October 23, 1935	50	60	65	57	49	21	56	80	12.8	2.86
TRIAL No. 12: Guinea grass fert. N only first cutting	December 16 to Dec. 26, 19236	53	56	45	57	59	28	56	86	16.1	2.08
TRIAL No. 7: Guinea grass fert. N and P first cutting	November 4 to Nov. 14, 1936	53	61	56	55	58	24	63	77	13.6	2.24
TRIAL No. 14: Guinea grass fert. N and P first cutting	January 6 to Jan. 16, 1937	53	54	62	60	58	11	58	89	18.0	1.93
TRIAL No. 8: Malojillo or Para grass fert. N only first cutting	November 4 to Nov. 14, 1936	62	66	61	64	64	42	71	88	12.7	2.06
TRIAL No. 27: Malojillo or Para grass fert. N only 2nd. cutting	April 28 to May 8, 1937	63	42	68	63	67	40	65	97	46.7	1.205
TRIAL No. 26: Malojillo or Para grass fert. N & P 2nd. cutting	March 15 to March 25, 1937	50	39	68	49	55	27	52	89	30.0	1.86
TRIAL No. 25: Malojillo or Para grass fert. N & P 2nd. cutting	April 17 to April 27, 1937	32	17	54	49	61	19	51	91	87.0	1.70

TRIAL No. 9: Guatemala grass fert. N only first cutting	November 25 to Dec. 5, 1936	68	60	79	71	69	49	70	84	20.6	1.45
TRIAL No. 23: Guatemala grass fert. N only second cutting	March 26 to April 5, 1937	60	54	77	60	63	40	61	81	25.2	1.24
TRIAL No. 23: Guatemala grass fert. N and P first cutting	November 25 to Dec. 5, 1936	63	56	74	66	65	44	65	85	20.4	1.34
TRIAL No. 10: Guatemala grass fert. N and P second cutting	March 26 to April 5, 1937	66	58	74	60	72	41	68	86	23.1	1.30
TRIAL No. 24: Yaragua grass fert. N only second cutting	April 6 to April 16, 1937	50	5	33	58	50	9	53	88	354.0	2.14
TRIAL No. 17: Yaragua grass fert. N and P second cutting	February 20 to March 2, 1937	42	24	53	54	42	3	47	90	54.0	2.14
TRIAL No. 26: Yaragua grass fert. N and P second cutting	April 17 to April 27, 1937	42	22	43	45	48	Neg. bal.	50	85	66.2	1.59

Note: "N and P" stands for nitrogen and phosphorus in the fertilizer.
"N" stands for nitrogen only in the fertilizer.

TABLE 12

VITAMIN A ACTIVITY OF CROPS

Crops	Vitamin A Units per gram (Sherman)
Para grass leaves	200
Guinea grass leaves	200
Guatemala grass leaves	270
Elephant grass leaves	200
Yaragua grass leaves	100
White pigeon peas, (flowers, stems, leaves, air-dry)	333
Velvet Beans (pods, leaves and stems, air-dry)	135

A COMPARISON OF METHODS OF DETERMINING CARBON IN SOILS

CARLOS ESTEVA JR.[1]

INTRODUCTION

For the determination of organic carbon in soils various methods have been proposed and they may be classified as followows:

1. Dry combustion:
   (*a*) Furnace combution.
   (*b*) Bomb combution or Parr's method. An oxidation with sodium peroxide in which sodium carbonate is formed.
2. Wet combustion: In which the material to be analyzed is treated with a mixture of chromic and sulfuric acids. Various modifications of this method have been proposed.

It has been shown experimentally that the dry combustion methods give higher results than the wet combution, but the former have certain disadvantages which may be summarized in the following way. The dry combustion methods require a rather complicated and expensive equipment and it is somewhat more difficult to manipulate. In some cases (especially in the furnace dry combustion) the determination is very long and tedious. The wet oxidation methods are adaptable for the estimation of carbon, both in solutions and in dry substances, while the dry combustion methods are only adaptable for the estimation of carbon in dry substances.

Naturally, the aim of many investigators had been to obtain a wet ovidation method, capable of determining the total carbon in amounts that would compare with the dry combustion methods.

White and Holben (**14**) claim that they have found the ideal method: a wet oxidation process which is capable of determining amounts of carbon identical with those obtained by the dry combustion methods.

This work was undertaken with the purpose of comparing the relative efficiency of the chromic acid method as given by White and Holben (**14**) and the official method as given by the Official and Tentative Methods of Analysis of the Association of Agricultural Chemists (**7**), with the Parr's dry combustion process.

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[1] The writer wishes to express his obligation to Dr. J. A. Bizzell under whose direction and help this work was undertaken.

Review of Literature

In 1848 Rogers and Rogers (**9**) devised a wet oxidation method for the determination of carbon in native and artificial graphites. The oxidizing agent employed in this process was a mixture of bichromate of potassium and sulfuric acid, which the authors claimed, that when applied to graphite, under the conditions given, converted the carbon rapidly and completely into carbon dioxide. The process was gravimetric.

In 1880 Warington and Peake (**12**) furnished data which led to the conclusion that oxidation of carbon in soils by means of a mixture of chromic and sulfuric acids gave results lower than those obtained by the furnace combustion in a current of oxygen. The mode of procedure was quite similar to that recommended by E. Wolff in his "Anleitung zur Chemischen Untersuchung Landwirthschaftlich Wichtiger Stoffe". The materials were kept below their boiling point by heating in a water bath. They stated, however, that the complete destruction of the humic material in the soil does not necessarily imply that the carbon has been entirely converted to carbon dioxide. They used a gravimetric method. The oxidation with the permanganate method, as used by the authors indicated higher result than with chromic acid; but even the permanganate method failed to convert the whole of the carbon to carbon dioxide, the product with the permanganate being, on an average of 4 soils, 92.4 per cent of that yielded by the combustion in oxygen.

In 1904 Cameron and Breazeale (**4**) confirmed the ideas of Warington and Peake (**12**) by stating that the oxidation of carbon in soils by the mixture of chromic and sulfuric acids gave results lower than those obtained by the furnace combustion. But they concluded that the combustion of a soil by the wet method with chromic acid mixture, as described in their paper, would give a more accurate idea of the organic matter in the soil, than the furnace combustion method. Beside the method was more rapid.

n this same year Parr (**8**) published his new method of determining carbon. The combustion of the organic material is affected by means of sodium peroxide, the charge being contained in a closed bomb or cartridge surrounded by water. He claims that the method is much more accurate than the various forms of alkalimeters, which were tried for comparison, and that its ease of manipulation renders it preferable to the absorption method, especially for technical work.

Hall and Miller (**6**) in 1906 reexamined the chromic acid method and concluded that the error was due to incomplete oxidation, other

substances than carbon dioxide being produced. They found that by passing the products of combustion over heated copper oxide all the carbon would be obtained as carbon dioxide.

Ames and Geither (1) in 1914 concluded that if boiled for 30 minutes a mixture of 3.3 grams chromic acid in 10 cc. water to 50 cc. of sulfuric acid (sp. gr. 1.84) will oxidize all the organic carbon and liberate carbon dioxide chemically or mechanically held in soils, provided the soil is ground to pass thru a 60 mesh sieve. One to three grams of soil were used for each 60 cc. of mixture. They made no attempt to prevent the acid fumes passing into the carbon dioxide absorption tower. They used a wet combustion volumetric method.

Schollenberger (10) in 1916 suggested certain improvements in the method described by Ames and Gaither (1). The changes referred to, consist of the use of a mixture of phosphoric and sulfuric acids, instead of sulfuric acid alone, with chromic anhydride as the oxidizing agent. Also the substitution of barium hydroxide for sodium hydroxide as the alkaline absorbent for carbon dioxide. He also suggested the replacement of the modified Camp absorption by the Meyer absorption apparatus or Truog's bead tower, together with changes in procedure made necessary by the changes in the reagents employed. The partial substitution of phosphoric for sulfuric acid reduces to a negligible quantity the fuming noticed when sulfuric acid is used alone. Phosphoric acid alone gave invariably lower results.

Gortner (5) in 1916 kept the digestion mixture below the boiling point for 2.5 hours and passed the products of combustion thru a heated combustion tube.

Finally in 1925 White and Holben (14) published their new method entitled, "Perfection of Chromic Acid Method for Determining Organic Carbon". The authors claim that their method has the following advantages. (1) The sulfur-trioxide absorption tube, used for the first time in this study greatly simplifies the usual analytical procedure. (2) Eliminates the use of a combustion tube. (3) The proposed method has the advantage over the dry combustion method in that it eliminates the possibility of leaving behind the residue of undecomposed carbonates. (4) It may be used for the estimation of carbon both in solution and in dry substances. (5) The use of the proposed sulfur trioxide absorption tube eliminates the necessity of secondary combustion. (7) The results compare with the furnace comustion with CuO and with th bomb combustion.

Experimental

The plan of the investigation included the analysis of 25 soil samples, of high and low carbon content, representative of the type found in the State of New York. The analysis included determinations of organic carbon by the Official Wet Oxidation Method and the chromic acid method of White and Holben (**14**). The results were compared with those obtained by Waterman (**13**) following the Parr combustion procedure.

Soils Used: The samples were taken by the Department of Agronomy (Cornel University) some years ago, and accurate records were taken of the location so that at any future time duplicate samples might be taken at exactly the same place.

Preparation of Sample: In general, soil samples were taken at a depth of eight inches by the method described in the Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists (**7**) .When received in the laboratory the samples were spread out and allowed to air-dry. The original air-dry samples were thoroughly mixed and a subsample taken for analysis. The subsamples were rubbed in a porcelain mortar, using a rubber tipped pestle, and then passed thru a sieve having circular perforation 1 mm. in diameter. The material not passing the sieve was discarded. The sifted subsamples were then ground in an agate mortar until they passed entirely thru a sieve having 100 meshes to the linear inch.

Organic Carbon: Was determined by analyzing for total carbon and then substracting the inorganic carbon obtained.

Description of Methods

I. The Official Wet Oxidation Method.

Detailed Procedure: With slight changes the procedure listed in page 25 of the Official Methods (**7**) was followed.

Having the apparatus set as in Figures 1 and the solutions prepared as given in the Official Methods (**7**) the order of procedure was as follows:

Two grams of the 100 mesh soil were placed in the evolution flash (Fig. 1). The apparatus was freed of atmospheric carbon dioxide by suction and then 30 cc. of 0.5 N NaOH were introduced into the absorption tower. Gentle suction was applied and 10 cc. of the oxidizing solution were run into the evolution flask. Twenty-five cc. of the acid mixture were then added, the contents gently agitated and a low flame placed under the flask. The heating was continued for 30 minutes after the mixture began to boil.

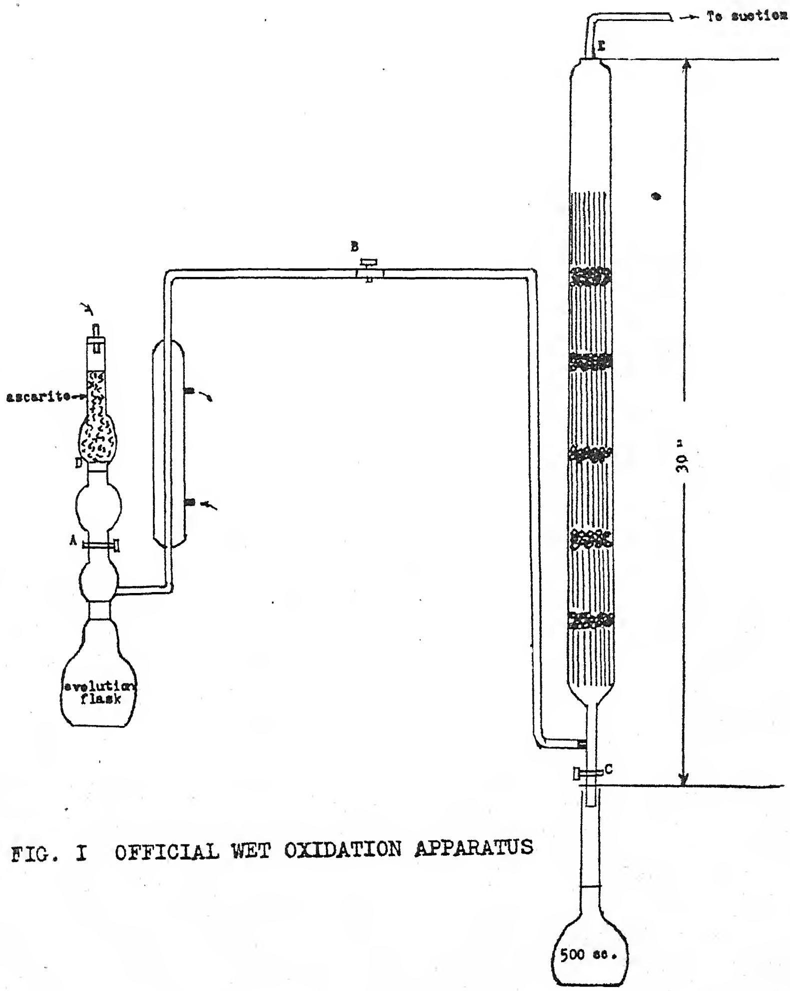

FIG. I OFFICIAL WET OXIDATION APPARATUS

The suction was released at the end of the agitation and aspiration and the absorbent was washed into a 500 cc. volumetric flask. By the addition of 10 cc. of a neutral aqueous solution of barium chloride (250 grams of $BaCl_2 \cdot 2H_2O$ per liter) the sodium carbonate in the volumetric flask was precipitated. Then it was diluted to volume and the precipitate of barium carbonate was allowed to settle. A 200 cc. aliquot was pipeted and the residual hydroxide was titrated against 0.5 N hydrochloric acid, using phenolphthalein indicator.

The difference between the residual hydroxide in terms of 0.5 N alkali and the 0.5 N sodium hydroxide originally used is equivalent to the carbon dioxide formed by oxidation of the organic carbon plus the inorganic carbon dioxide present in the sample.

For the determination of inorganic carbon the procedure as described above was followed using the fololwing modifications: (1) 10 grams of soil were used, (2) oxidizing solution was omitted, (3) 60 cc. HCl (1 : 9) were substituted for the acid solution. (4) The flask was agitated but not heated.

When the apparatus is set as described previously, that is: using 2 grams of soil and 30 cc. of 0.5 N sodium hydroxide in the absorption tower, it cannot determine soils which are higher than 4.498 per cent of total carbon. Soil which are higher in total carbon than the above mentioned figure need that only one gram sample should be used or else use 45 cc. of 0.5 N sodium hydroxide in the absorption tower.

Suction troubles and leakages in the rubber tubing were the principal troubles which I encountered in dealing with this apparatus. The suction must be slow and uniform otherwise the gas liberated in the reaction would pass thru the absorption tower with imperfect absorption of the gas. This may be incidental to loss of carbon dioxide and the spoiling of the determination. The suction should be arranged so that bubbling thru the absorption tower should be as constant as possible. About 30 to 50 bubbles per minute are sufficient.

When emptying the contents of the absorption tower into the 500 cc. volumetric the tower was washed 3 or 4 times with pure distilled water. After completing to volume the tower was drained thoroughly.

A strong flame while boiling was very undesirable as it forced the acid fumes in the evolution flask to pass uncondensed to the absorption tower.

The painting of rubber connections with white shellac (Devoe and Reynolds Co., Inc., N. Y.) was found to be very desirable.

Thick rubber connections were more efficient because they lasted longer in good working order than the thin-walled rubber connections.

Another precaution that was followed was to avoid the use of grease in the glass connections of the Knorr carbon dioxide apparatus.

Notwithstanding the many precautions taken to obtain the 0.5 N sodium hydroxide absolutely free of CO_2, it was found to be absolutely impossible. The presence of carbon dioxide was noticed when barium chloride was added to the alkali, in which case a very faint white precipitate was noticed. In order to see the effect of the CO_2 on the titration of the absorbent solution the following test was performed.

The 30 cc. of 0.5 N NaOH, quantity which was used for absorbing the CO_2 in the Official Method apparatus, were placed in the absorption tower. Then drained, completed to volume in the volumetric flask and finally aliquots were taken and titrated against 0.5 N HCl.

Results obtained:

Aliquot	*Titration with 0.5 N. HCl*
No. 1—200 cc.	12. cc.
100 cc.	5.95 cc.
No. 2—200 cc.	12.05 cc.

We might conclude then that the effect of the carbon dioxide dissolved in the alkali was negligible as far as the accuracy of the method is concerned.

II. Method of White and Holben (**14**).

The procedure as described by White and Holben (**14**) was followed as carefully as possible. The apparatus is shown in Fig. 2.

Two grams of soil were placed in the generating flask, M. Tubes F and I were connected by means of a glass tube and air was pulled through for several minutes Valve C was closed and the aspirating continued for a short time to test the apparatus and at the same time to create a partial vacuum at M. F and I were closed and the weighed tubes G and H were attached. K is detached from L and 4 grams chronic acid (CrO_3) dissolved in 10 cc. water were placed in the bulb L. K was conected to L and the solution run into flask M. Fifty cc. H_2SO_4 (sp. gr. 1.83 — 1.84) were then run into M in a similar manner leaving open valve C. Air was then pulled again thru the apparatus and the solution brought to boil. The solution was then boiled for 30 minutes during which time air was pulled through at the usual rate. Then tubes G and H. were removed, wiped, and weight after an interval of 15 minutes.

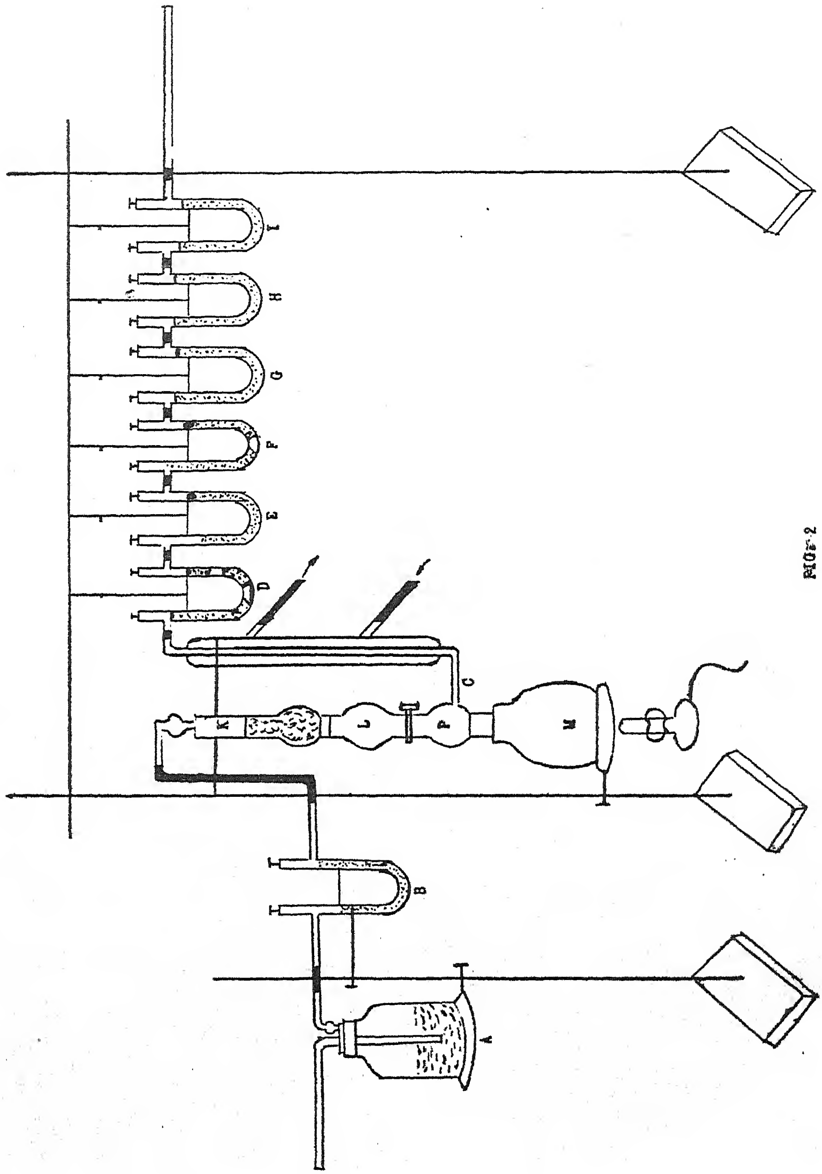

FIG. 2

Weighing of the soda-lime and acid-drying tubes required certain precautions. It was necessary to wipe the tubes and weigh them after 15 minutes in order to get equilibrium of the electrical effect created by the wiping. Tubes G and H were weighed against a common counterpoise tube of the same size made up to weight with 3 grams of the soda lime and acid-pumice tubes. Just before weighing each tube the valves were opened for an instant to equalize the inside and outside atmospheric pressures. Certain modifications of this method were tried. One of them was the substitution of ascarite absorbent for the soda-lime carbon dioxide colelcting tube. The other was the substitution of the Allihn gas-washing bottle containing 1 : 1 potassium hydroxide for ascarite in an ascarite bottle.

The results may be summarized as follows:

No. 1—Using ascarite as gas absorbent + ascarite air purifier.

Soil No.	*% Organic Carbon*
11A	1. 4075
11A	1. 3775

No. 2—Using soda-lime as absorbent + KOH air purifier.

Soil No.	*% Organic Carbon*
11A	1. 3498

No. 3—With ascarite as CO_2 absorbent + KOH air purifier.

Soil No.	*% Organic Carbon*
3A	2. 9150

No. 4—With apparatus as designed by the authors.

Soil No.	*% Organic Carbon*
3A	2. 9161

From these figures we might conclude that ascarite is as good an absorbent as soda-lime and that it can be freely substituted for the soda-lime in this determination. Also a nascarite bottle is as efficient a purifier of the air as is the Allihn gas-washing bottle containing 1:1 potassium hydroxide.

After the preliminary tests the experiments were carried out in exactly the same way as described by the authors. A slight variation was made in the suctioning process in which suction from a faucet was used instead of the aspirator used by the authors. But it is supposed that this change did not affect the results of the experiments.

This gravimetric method as given by White and Holben **(14)** has certain sources of error which can only be overcome by a very care-

ful techinque. In fact any gravimetric process for the determination of carbon has decided disadvantages attending to the use of the absorption tubes. Some of the sources of error which may alter the results of this gravimetric process and which may be incident to loss of time are:

(1) It requires very elaborate precautions to prevent changes of weight of the tube due to gain or loss of moisture, necessitating complications in the purifying train and the use throughout the apparatus of drying agent of the same hygroscopic power.

(2) Difficulties in weighing large glass vessels caused by electrical effects in wiping, by buoyancy, and by changes in temperature between the balance room and laboratory.

(3) The liability to error from access of gases containing sulfur and chlorine, which may be formed during combustion of the metal or of the carbonaceous residue therefrom. The difficulty had been avoided in the chromic acid method by the use of an U tube fitted with glass beads and a saturated solution of silver sulfate in 5 per cent sulfuric acid.

(4) The difficulty of determining whether the increase in weight of the tube is due solely to the carbon dioxide.

(5) The time lost in waiting for the absorption tubes to reach equilibrium before weighing.

If the complicated purifying train gets out of order or if the tube itself introduces errors in some way, it may often be difficult to locate and correct the trouble. In actual practice with this method this last experience unfortunately occurred and it was after much working that the source of error was located in one of the U tubes whose stopper was not air tight and was thus leaking.

III. Parr's Dry Combustion Method.

The following description of the method is taken from Waterman's (3) thesis.

1. Place 1 gram soil, 5 gm. Na_2O_2, .75 gms. magnesium powder in the bomb, close, screw tight and explode by holding in a gas flame. Cool under tap.

2. Uuscrew cap and wash charge into the 150 cc. flask, using boiling water in wash bottle. Boil the solution to remove excess oxygen and to fill the flask with water vapor.

3. While boiling the solution, raise the levelling tube till the burette is filled with mercury. Then shut stopcock. Close stopcock into acid funnel.

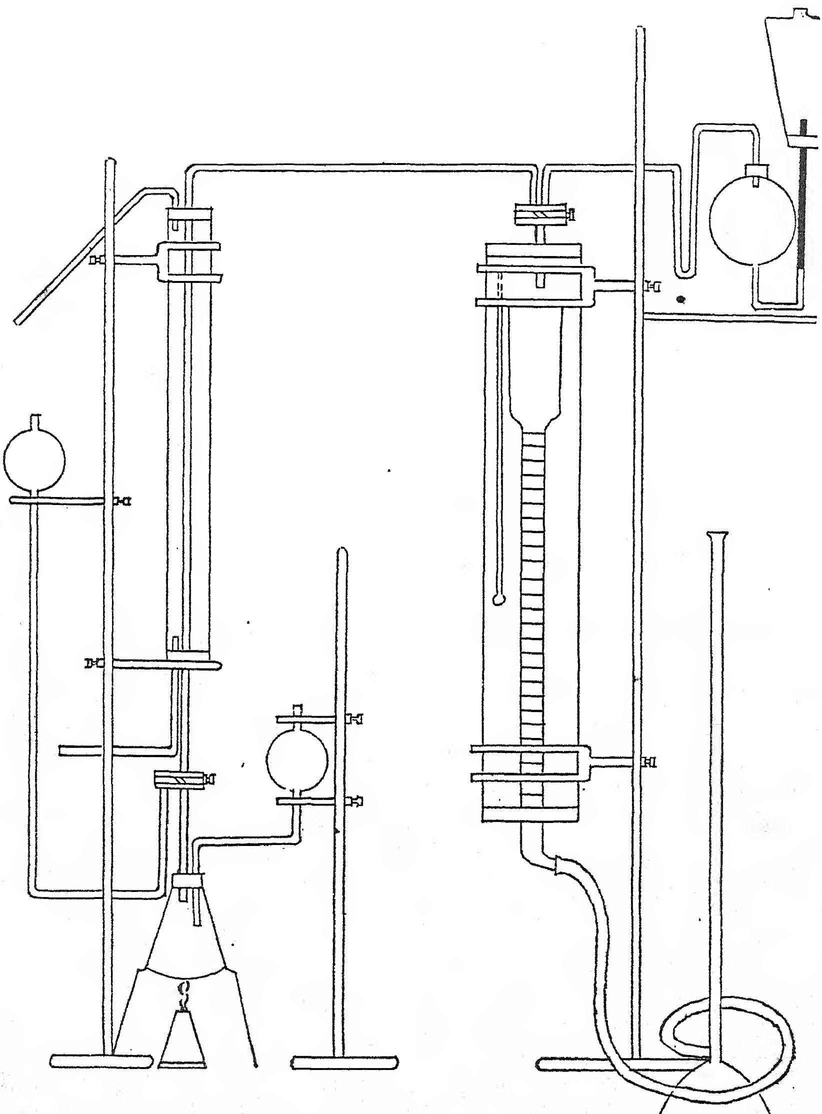

FIG. 3 PARR'S DRY COMBUSTION APPARATUS
Used by Stirling Waterman

4. Place the 150 cc. flask in place and gradually open the cock connecting the condenser with the burette. (Caution). If opened too quickly solution will boil up and pass over into burette.

5. Place 50 cc. 1 : 1 H_2SO_4 in acid funnel and allow to run *slowly* into flask.

6. When all H_2SO_4 is run in, close stopcock and boil solution for ten minutes controlling heat so that water will not pass into the burette.

7. Fill acid funnel with cold, recently boiled, CO_2 free, water. Allow it to run into flask until the water rises to the first stopcock. Then shut it off and connect with mercury funnel. By raising it, fill the tube right to the burette with mercury. All the gas is now in the burette.

8. Close the stopcock at the top of the burette, lower levelling tube to a convenient level and draw in air through the pipette. Then close the stopcock, raise levelling tube until both columns are level and read. The level of the KOH in the pipette should be noted.

9. Then open cock, pass gas up to 100 cc. mark into the pipette, close cock and shake to absorb the CO_2. Return the unabsorbed gas to the burette so that level of KOH is the same as in 8. Close stopcock, level the mercury and read. Difference is CO_2.

10. Again lower levelling tube as before, allow air to enter and repeat the operation. The CO_2 envolved by one gram generally requires two to five such operations—more from two grams.

11. Note temperature of gas, and barometric pressure and calculate the volume of CO_2 present at 0°C and 760 mm. pressure. Then calculate the per cent total carbon.

12. The carbonate CO_2 is measured in the same way, adding 10 gms. of soil to 50 cc. water in the flask and boiling before placing on the apparatus. The rest of the operation is the same as above described.

A comparison of the Official Method and the Parr dry combustion shows the fact 14 out of 24 samples agreed within a difference of 0.2 per cent, the majority of them much more closely, and the differences being in either direction. The agreement is fairly good when we consider that the analyses were made by different individuals, using different methods. Furthermore, the samples that do not agree within a 0.2 per cent difference are pretty close to it, with the possible exception of soil 3A. The analysis of this sample by the Parr method shows a very low figure, but there is some reason to believe that something might be wrong with that figure since the other methods agreed with the expected difference.

RESULTS

COMPARISON OF 3 METHODS OF DETERMINING CARBON IN SOILS

Sample No.	Soil Type	Per cent organic carbon air-dry sample		
		Official Wet Combustion Method	Method of White & Holben	Parr's Combustion Method
16A	Ontario Loam	1.78	1.47	2.14
14A	Ontario Loam	1.85	1.67	1.69
27A	Ontario Loam	3.09	2.85	3.21
48A	Ontario Loam	1.50	1.28	1.60
57A	Ontario Loam	2.35	1.77	1.98
61A	Ontario Loam	1.65	1.38	1.65
56A	Ontario Loam	1.59	1.30	1.66
58A	Ontario Loam	1.91	1.89	2.17
7A	Volusia stony silt loam	2.55	2.27	2.86
54A	Volusia stony silt loam	5.41	4.54	5.32
34A	Volusia stony silt loam	2.79	2.45	2.32
3A	Volusia stony silt loam	3.15	2.97	2.26
49A	Volusia silt loam	1.65	1.47	1.58
12A	Volusia silty clay loam	2.67	2.45	2.74
66A	Vergennes clay	2.50	2.28	2.58
67A	Vergennes clay	2.82	2.45	2.75
65A	Vergennes clay	2.23	1.98	1.91
55A	Wooster gravelly silt loam	2.64	2.40	3.01
53A	Wooster silt loam	3.22	3.27	3.55
22A	Honeoye silt loam	2.14	1.96	2.24
32A	Dutchess silt loam	2.82	2.46	2.54
28A	Gloucester loam	2.56	2.32	2.53
11A	Dunkirk silt & clay loam	1.81	1.38	1.86
8A	Lordstown stony silt loam	3.71	3.42	3.67
63A	Worth loam	2.66	2.39	(1)

(1) Figures not available for this sample by the Parr dry combustion method.

The agreement between the methods of White and Holben (**14**) and the Parr Combustion (**13**) is not very satisfactory, the former giving uniformly low results which represent approximately 90 per cent of the total carbon obtained by the Parr method.

It would appear from these results that the official wet oxidation method is more accurate than that described by White and Holben (**14**). It appears also that the latter has the disadvantage of more complicated equipment and requires more care and time in the manipulation.

SUMMARY

1. Total carbon was determined in 25 samples of soil using the Official wet oxidation method and the chromic acid method of White and Holben (14). The results were compared with those obtained by Waterman (**13**) with the Parr dry combustion method.

2. The Official wet combustion method compared favorably with the absolute method of Parr.

The method of White and Holben (**14**) gave consistently low results.

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A MODIFICATION OF MITSCHERLICH'S METHOD FOR THE DETERMINATION OF THE NUTRIENT CONTENTS OF A SOIL

By BERNARDO G. CAPÓ.
(Graphs and Diagrams by Fernando Chardón.)

INTRODUCTION

To find the relation that exists between the concentrations of plant nutrients in a soil and the yield of the crop planted in it, has been for a long time one of the main problems tackled by agricultural chemists all the world over. Among the many investigators who have worked along this line, E. A. Mitscherlich has startled his colleagues by making a series of bold assertions with respect to this problem.

Mitscherlich's theories have been both attacked and defended with too much zeal. In fact, in many cases the scientific point of view has been overlooked, and both attackers and defenders have arbitrarily discarded data which would prove unsatisfactory for their own point of view.

To determine to just what extent Mitscherlich's theories apply to plants grown under Puerto Rican conditions and the possibility of the application of said theories to the furtherance of Puerto Rican agriculture have been objects which the author has tried to attain in complying with the requisites of the project under which this work has been performed.*

MITSCHERLICH'S THEORIES

Mitscherlich has stated that the relation between the initial concentration of any given plant nutrient in a given soil and the yield of the plants grown in it may be represented by an equation of the type:

$$y = A(1-K^x) \qquad (1)$$

where "y" is the yield of the crop obtained with the initial concentration "x" of the plant nutrient, "A" is the maximum yield obtainable with unlimited increases in the initial concentration of said plant nutrient, and "K" is a constant corresponding to the nutrient under study.

* This work has been performed under Project No. 2, Bankhead-Jones Fund.

To calculate the values of the constants "A" and "K" which are applicable to a given set of conditions, it is necessary to know at least the yields produced, under the required set of conditions, with two different initial concentrations of the plant nutrient. The corresponding values for "x" and "y" are substituted in equation (1) above, and the resulting equations are solved for "A" and "K".

If only the yields produced with two different initial concentrations of the plant nutrient are known, the substitutions will provide only two equations in the two unknowns "A" and "K". These are solved, therefore, simultaneously.

If the yields produced with more than two different initial concentrations of the plant nutrient are known, the substitutions will provide more than two equations in the two unknowns "A" and "K". These should be solved, therefore, by the Method of Least Squares in order to obtain the most probable values of the constants "A" and "K".

With the values of "A" and "K" as obtained by either of the two methods referred to above, an equation of the type of equation (1) may be written to express the relation that exists between the initial concentration of the plant nutrient and the yield of the crop which is produced in its presence under the given set of conditions. With this equation it is possible to calculate the yield of the crop which would be produced, under this set of conditions, by any initial concentration of the plant nutrient.

However, the equation which shows the relation between the initial concentration of a nutrient in a given soil, with its own set of climatic conditions, and the yield of the crop planted in it must also provide for the specific available nutrients in that soil.

The equation is therefore, modified into one of the type

$$y = A(1 - K^{b+x}) \qquad (2)$$

where "y", "A" and "K" mean the same as in equation (1), and now "b + x" is the initial nutrient concentration; "b" being the respective nutrient concentration in the unmanured soil and "x" the increase in nutrient concentration produced by the addition to the soil of materials containing said nutrient.

This equation contains, therefore, three constants or parameters whose values must be determined. In order that the values of these constants may be calculated it is necessary that at least three yields produced with three different applications of the nutrient be known.

If only three such values are known, due substitutions for "x" and "y" are made in equation (2) and the resulting three equations solved simultaneously in order to find the values of "A", "K" and "b".

If more than three yield values with the corresponding nutrient applications in whose presence they were produced are known, the substitutions in equation (2) will furnish more than three equations in these three unknowns and these equations must then be solved by the Method of Least Squares in order to obtain the most probable values of the constants "A", "K" and "b".

The value of "b" found in either of these ways is therefore the nutrient content of this soil for this respective nutrient. The application of equation (2), therefore, affords a method for the determination of the content by a soil of any given plant nutrient.

This method requires: the application to given equal amounts of soil, of three different amounts of the plant nutrient under study, the growth of a crop in each of these soil portions, the weighing of these crops, the substitution of the values of nutrient applications and corresponding crop yields for "x" and "y" respectively in equation (2), and the mathematical solution of these equations for "b".

This means that for the determination of the content by the soil of any plant nutrient, in a form as available to a given plant as the form in which the plant nutrient is used, an experiment must be performed with at least three different applications of said plant nutrient in the desired form. If it is required to determine the soil contents of the three principal nutrients, (nitrogen, phosphoric acid and potash), it is necessary that one of such experiments be performed with each of these plant nutrients, making a total of nine different treatments. Three of these treatments may be equal, reducing the total number to seven treatments. With this procedure, therefore, it is possible to calculate the soil contents of the three principal plant nutrients.

Mitscherlich has announced, however, that the constant "K" corresponding to a plant nutrient is the same for all crops and in all soils. He has stated, in fact, that the following values hold for these nutrients under all conditions, when the nutrient amounts are expressed in doublezentners per hectare:

For ammonia (NH_3):	$K = 10^{0.10}$
For phosphoric acid (P_2O_5):	$K = 10^{0.60}$
For potash (K_2O), sodium present:	$K = 10^{0.93}$
For potash (K_2O), sodium absent:	$K = 10^{0.33}$

The constancy of these "effect factors", as claimed by Mitscherlich, led him to devise a simplification of the experimental scheme described above. Since the values for the different "K's" are fixed, the determination of the soil content of a plant nutrient can be done with only two different applications of said plant nutrient, since the values of only the two parameters "A" and "b" must be found. For the study of the soil contents of all three principal nutrients a total of six different treatments would be required, which number reduces to only four different treatments, since three of the six treatments may be equal. In this way the procedure of finding the nutrient contents of a soil is very simple. If to this is added the fact that these experiments can be performed with advantage in pots, where the conditions under which all treatments act may be carefully controlled, this procedure may afford a most simple and accurate method to do these determinations. Only one requisite is lacking. That it will work. Which leads us to our experimental work, which began with some experiments designed to determine whether this simple procedure gives reliable results.

Experimental Work

To date ten different pot experiments and one field experiment have been performed in five different soil types. The field experiment was performed on a field from which a soil sample had been taken for a pot experiment. The corresponding pot and field experiments thus check one another and their results serve as indications of the reliability which may be put on the results of pot tests of the type here preferred. These two experiments are the ones which will be presented as the experimental work on which the conclusions obtained from this work have been mainly based. The results of the other pot experiments, and of a field experiment performed with eggplants at the Isabela Sub-Station farm following the plan used in our field experiment, are in line and corroborate fully the conclusions derived from the two experiments presented here.

Pot Experiment With Vega Baja Silty Clay

The Vega Baja silty clay consists of a slightly mottled alluvial gray brown top soil lying over yellow brown and red mottled stiff clay. The soil sample for this experiment was taken from field 1D

of the Station farm, where the field experiment that follows this one was established. The soil was air dried and sieved through a 0.25 inch diameter circular hole sieve. The sieved soil was well mixed and one kilogram samples taken for each pot. Mitscherlich's enameled pots with circular openings at the bottom with capacity for 6 kilogram samples were used. The one kilogram of soil for each pot was mixed with 5 kilograms of Corozos sand and with the appropriate amounts of the nutritive salts before being transferred to the corresponding pot. The Corozos sand, a white quartz type of sand, was unwashed, but rapid chemical tests showed that it contained no nitrates, nor ammonium salts, no potash and only traces of phosphoric acid. This experiment was performed with Hegari Sorghum, a crop which previous pot tests had demonstrated to be the best among a series of standard grain and grass varieties as regards germination, speed of growth and freedom from disease and insect attacks, under greenhouse conditions at the Station.

Due to the good germinating power of the seeds only 40 seeds were planted in each pot, and 35 plants were allowed to grow until harvest time. The thinning was done on the fourth day after planting, the plants being already about 1½ inches high. Due to the rapid growth of the plants, Mitscherlich's watering procedure was varied. During the first days after planting the weight of each pot was raised by 200 g. daily, later on by 100 g. daily, then by 50 g. and finally by 25 g. daily until full water capacity was reached for each pot. After the water content of a pot had been brought to full water capacity the increases in weight were reduced to only 10 grams. That is, when it was found that a pot dripped, its weight was brought with distilled water to the same weight as on the previous day. If no water had percolated to the pan beneath, the weight of the pot was raised with distilled water by 10 grams. In this way the water content of each pot was brought to full water capacity every day.

The crop was harvested when the plants were about to head, that is, at the end of the vegetative period. On harvesting, all the material above the soil in each pot was cut with shears into pieces of about 1 inch in length and placed in a tared and numbered wire basket. The plant material was then dried to constant weight in a constant temperature electric oven at a temperature of about 115°C. Constant weight was assumed to be arrived at when the basket did not lose more than 0.1 gram after being in the oven for 3 additional hours. Table I summarizes the results of this experiment.

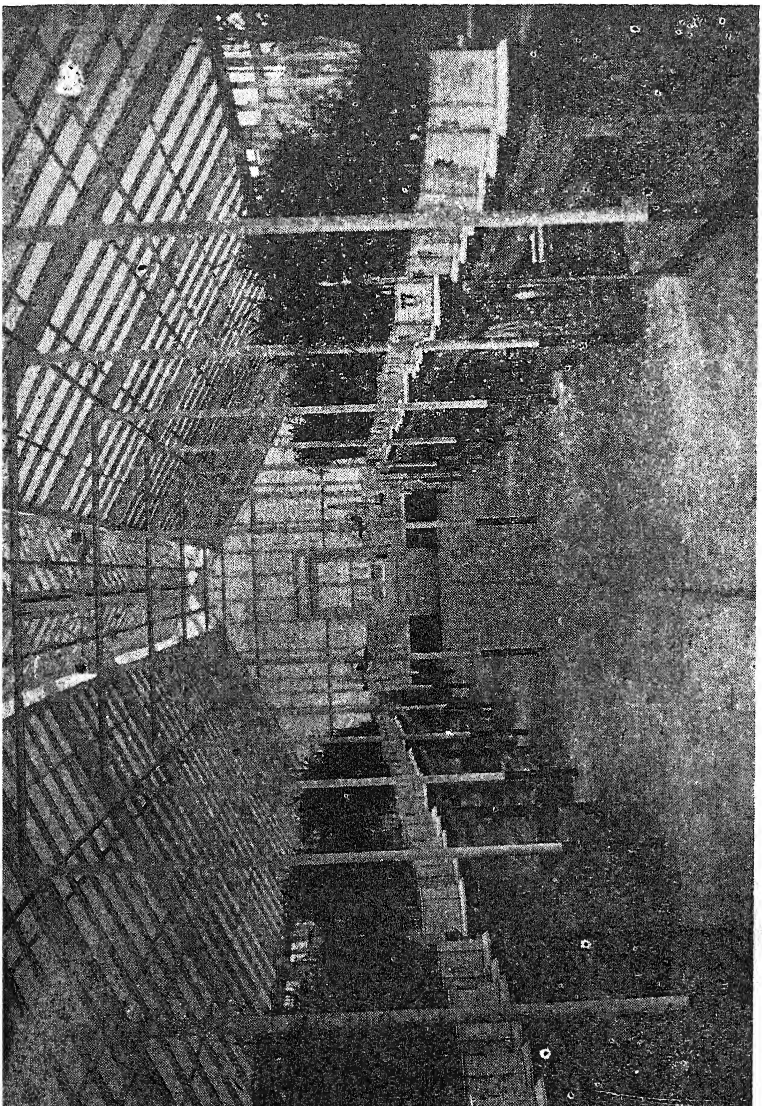


FIG. 1. Interior of the greenhouse where the pot experiment was conducted.

Treatments (in grams of substance per pot)				Yield (in grams of dry-matter per pot)				
				Replications				Average
No.	NH_3	P_2O_5	K_2O	1st	2nd	3rd	4th	
1	1.0227	0.1893	0.0000	31.0	25.6	27.9	27.0	27.9
2	1.0227	0.1893	0.1218	32.6	33.1	36.1	37.3	34.8
3	1.0227	0.1893	0.2436	43.0	40.2	37.5	42.3	40.8
4	1.0227	0.0000	0.3654	13.3	11.9	11.2	11.6	12.0
5	1.0227	0.0631	0.3654	25.3	24.3	25.9	25.8	25.3
6	1.0227	0.1262	0.3654	38.8	36.3	34.7	33.2	35.8
7	0.0000	0.1893	0.3654	10.5	10.1	10.4	10.3	10.3
8	0.3409	0.1893	0.3654	39.2	35.9	36.3	36.0	36.8
9	0.6818	0.1893	0.3654	44.1	45.0	41.5	39.1	42.5
10	1.0227	0.1893	0.3654	42.7	48.8	53.4	44.9	47.4
11	0.3409	0.0631	0.1218	20.8	21.8	21.8	21.7	21.5
12	0.6818	0.1262	0.2436	41.4	34.9	35.0	34.8	36.6

Table I.—Results of the Pot Experiment with Hegari Sorghum in Vega Baja silty clay.

Interpretation of the Results of the Pot Experiment: (*a*) The equation of the type of equation (2) above which fits best the average results obtained with treatments 1, 2, 3 and 10 is

$$y=891.6(1-0.94005^{0.5163+x}). \qquad (3)$$

This means that in this soil there are 0.5163 g. K_2O per kilogram in a form as available to the plants as the K_2O in K_2SO_4, which was the salt used to furnish the K_2O in this experiment. The fit between th actual yields obtained and those calculated by making use of equation (3) may be observed in Table II and Graph I.

Grams K_2O added per pot	Yields (in grams of dry-matter per pot	
	Actual	Calculated
0.0000	27.9	28.1
0.1218	34.8	34.6
0.2436	40.8	41.0
0.3654	47.4	47.4

Table II.—Comparison between the average yields obtained with treatments 1, 2, 3 and 10 and those calculated by making use of equation (3).

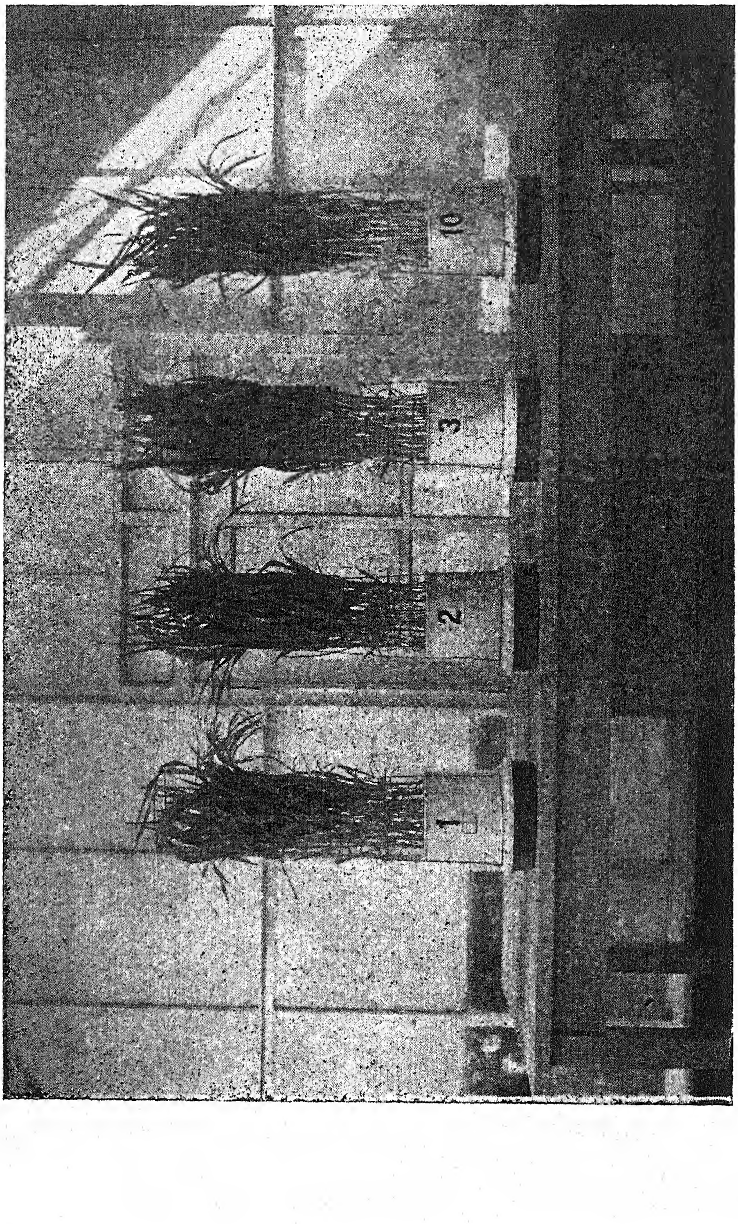
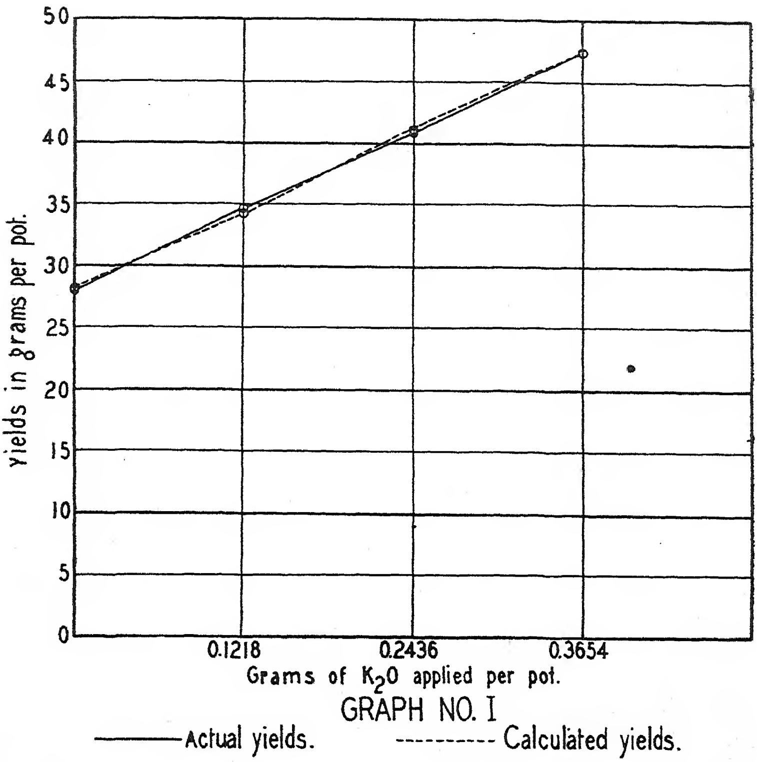


FIG. 2. View, at harvest time, of pots which had received treatments 1, 2, 3 and 10 respectively.



Graph I.—Comparison between the average yields obtained with treatments 1, 2, 3 and 10 and those calculated by making use of equation (3).

The good fit obtained in this case indicates that the constants of equation (3) have values which do not differ very much from the real values and that therefore the available K_2O content of this soil is close to 0.5163 g. K_2O per kilogram of soil.

(*b*) The equation of the type of equation (2) which fits best the average results obtained with treatments 4, 5, 6 and 10 is

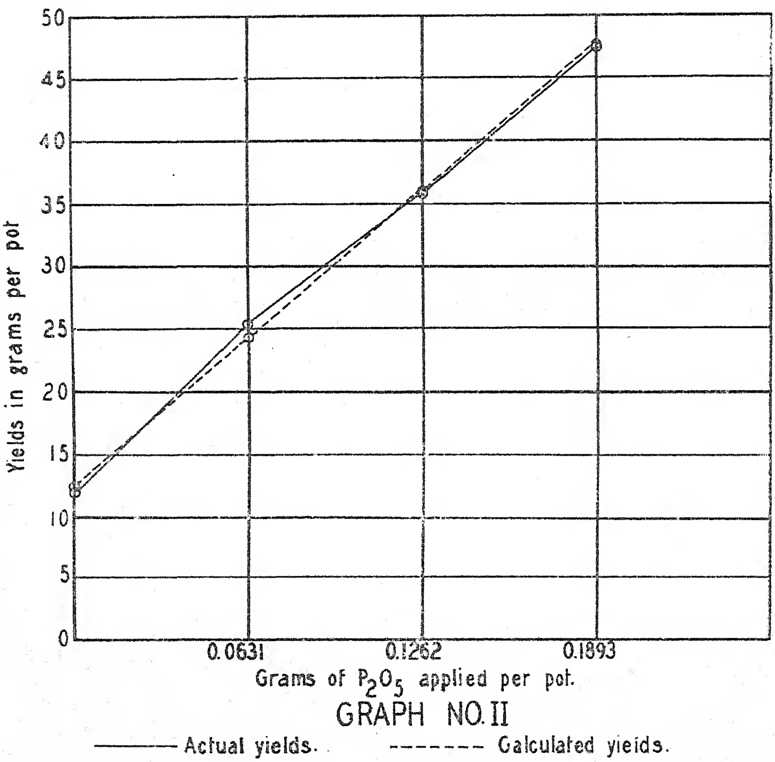
$$y = 1580.5(1 - 0.88752^{0.0670+x}). \qquad (4)$$

This means that in this soil there are 0.0670 g. P_2O_5 per kilogram in a form as available to the plants as the P_2O_5 in $Ca(H_2PO_4)_2H_2O$ which was the salt used to furnish the P_2O_5 in this experiment. The

fit between the actual yields obtained and those calculated by making used of equation (4) may be observed in Table III and Graph II.

Grams P_2O_5 added per pot	Yields (in grams of dry-matter per pot)	
	Actual	Calculated
0.0000	12.0	12.6
0.0631	25.3	24.3
0.1262	35.8	36.0
0.1893	47.4	47.6

Table III. Comparison between the average yields obtained with treatments 4, 5, 6 and 10 and those calculated by making use of equation (4).



Graph II.—Comparison between the average yields obtained with treatments 4, 5, 6 and 10 and those calculated by making use of equation (4).

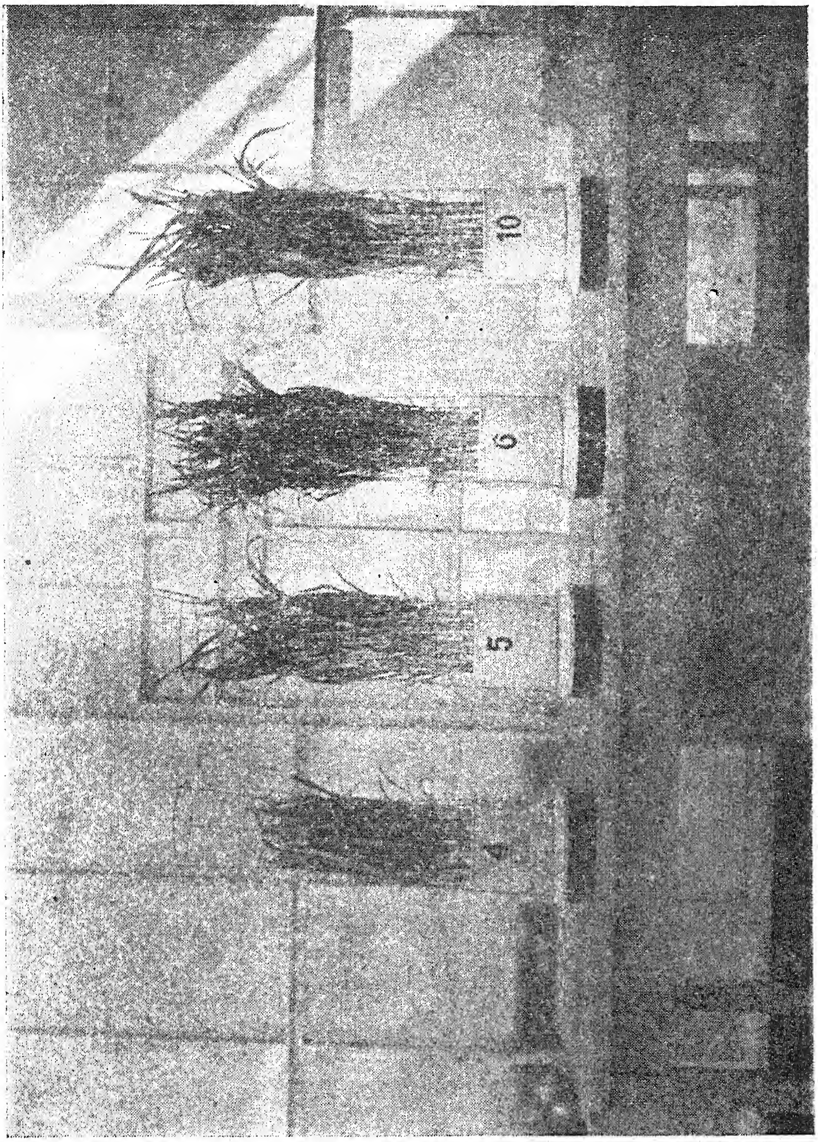


FIG. 3. View, at harvest time, of pots which had received treatments 4, 5, 6, and 10 respectively.

The good fit obtained in this case indicates that the constants of equation (4) do not differ very much from the values of the real constants and that therefore the available P_2O_5 content of this soil is close to 0.0670 g. P_2O_5 per kilogram of soil.

(*c*) The equation of the type of equation (2) which fits best the average results obtained with treatments 7, 8, 9 and 10 is

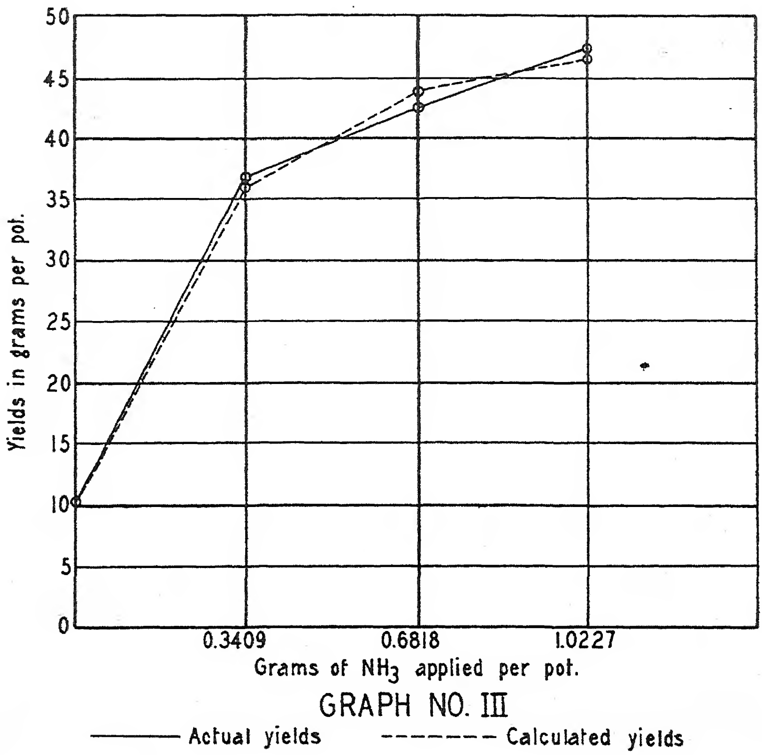
$$y = 47.53(1-0.0313^{0.0706+x}). \tag{5}$$

This means that in this soil there are 0.0706 g. NH_3 per kilogram in a form as available to the plants as the NH_3 in $(NH_4)_2SO_4$ which was the salt used to furnish the NH_3 in this experiment. The fit between the actual yields obtained and those calculated by making use of equation (5) may be observed in Table IV and Graph III.

Grams NH_3 added per pot	Yields (in grams of dry-matter per pot	
	Actual	Calculated
0.0000	10.3	10.3
0.3409	36.8	36.1
0.6818	42.5	44.0
1.0227	47.4	46.5

Table IV.—Comparison between the average yields obtained with treatments 7, 8, 9 and 10 and those calculated by making use of equation (5).

The good fit obtained in this case indicates that the constants of equation (5) have values which do not differ very much from their real values and that therefore the available NH_3 content of this soil is close to 0.0706 g. NH_3 per kilogram of soil.



Graph III.—Comparison between the average yields obtained with treatments 7, 8, 9 and 10 and those calculated by making use of equation (5).

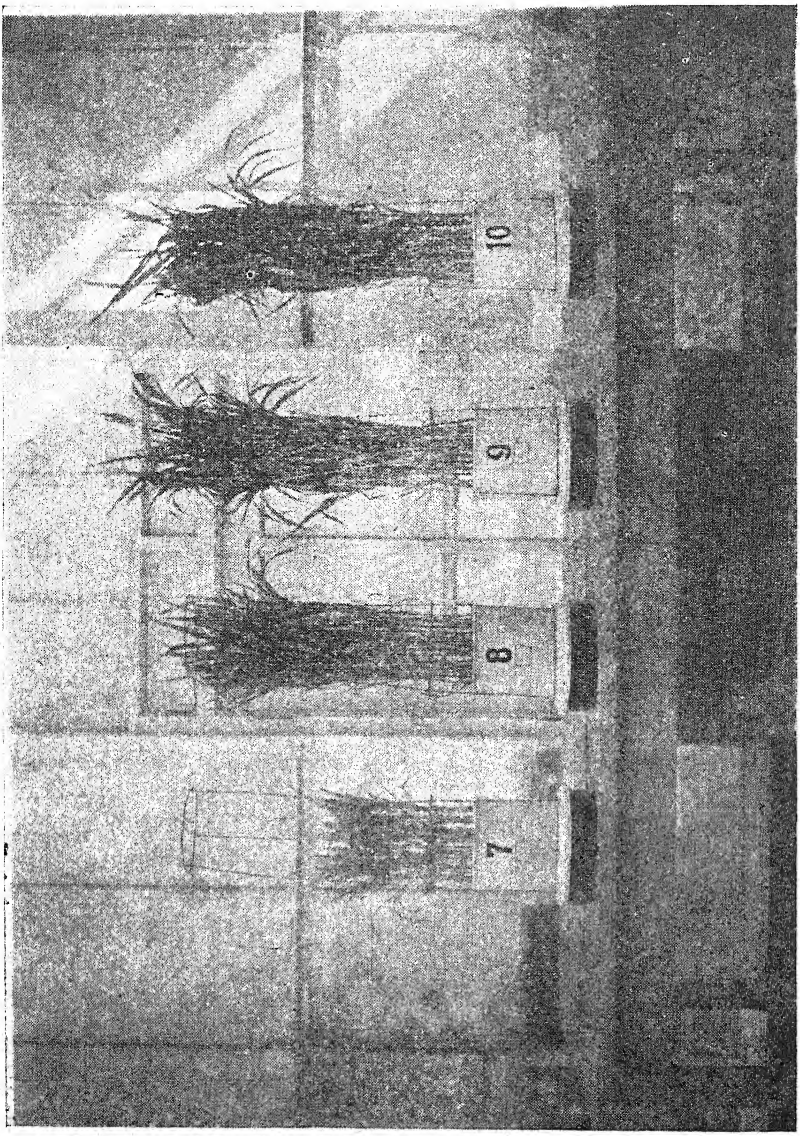


FIG. 4. View, at harvest time, of pots which had received treatments 7, 8, 9 and 10 respectively.

(*d*) Now, since according to Mitscherlich, the effect factors corresponding to the different nutritive elements are constant, it should be possible to write out a general equation relating the plant yields with the initial concentrations of these three nutrients. The general equation is of the following type:

$$y = A(1-R_1^{\ b_1+x_1})(1-R_2^{\ b_2+x_2})(1-R_3^{\ b_3+x_3}) \tag{6}$$

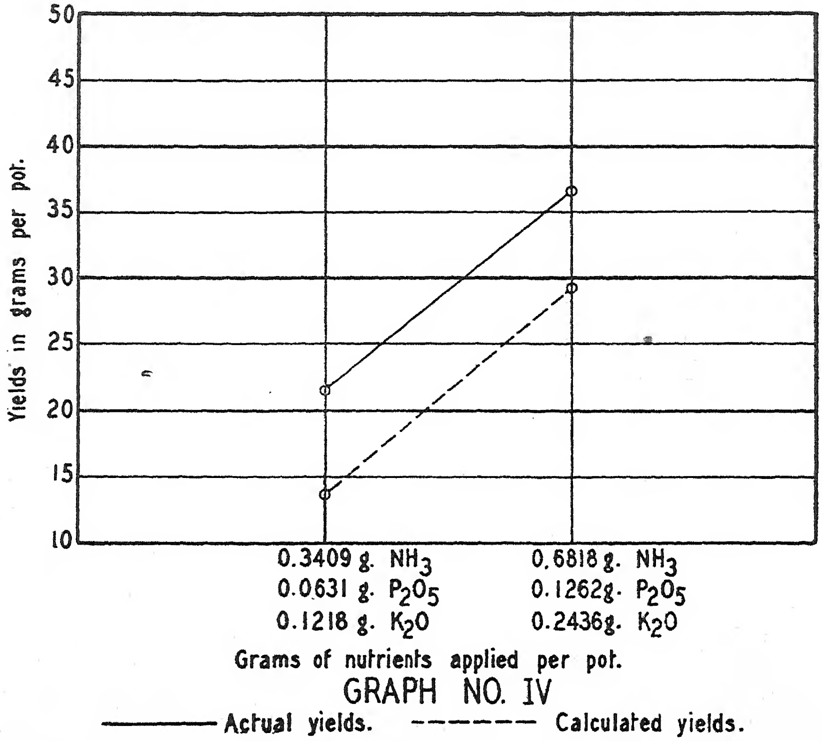
and in this particular case the calculated general equation is

$$y = 30210.2(1-0.0313^{\ 0.0706+x_n})(1-0.88752^{\ 0.0670+x_p})(1-0.94005^{0.5163+x_k}) \tag{7}$$

If Mitscherlich's assertion regarding the constancy of the effect factors were true, it should be possible to calculate with this equation the yields which would be produced with any known initial concentrations of all three plant nutrients. Treatments 11 and 12 were included in this experiment with the purpose of providing such a check. In Table V and Graph IV may be observed the fit between the actual yields obtained with treatments 11 and 12 and those calculated by making use of equation (7).

Nutrients added	Yields (in grams of dry-matter per pot)	
	Actual	Calculated
0.3409 g. NH_3; 0.0631 g. P_2O_5; 0.1218 g. K_2O	21.5	13.7
0.6818 g. NH_3; 0.1262 g. P_2O_5; 0.2436 g. K_2O	36.6	29.2

Table V.—Comparison between the average yields obtained with treatments 11 and 12 and those calculated by making use of equation (7).



Graph IV.—Comparison between the average yields obtained with treatments 11 and 12 and those calculated by making use of equation (7).

The poor fit obtained in this case indicates that equation (7) cannot be validly used for the calculation of yields produced under the conditions of the pots with treatments 11 and 12. This lack of agreement between the actual yields and those calculated by means of this equation is against Mitscherlich's affirmation with regard to the constancy of the effect factors.

Field Experiment in Vega Baja Silty Clay

This experiment was implanted on field 1D of the Station farm. The field was divided and the fertilizer treatments applied according to diagram No. 1. The manured plots, being 21.75 feet in length by 14.5 feet in width, were 1/138 acre in area. The NH_3 was applied as 25 per cent sulphate of ammonia, the P_2O_5 as 20 per cent superphosphate of lime and the K_2O as 50 per cent sulphate of potash.

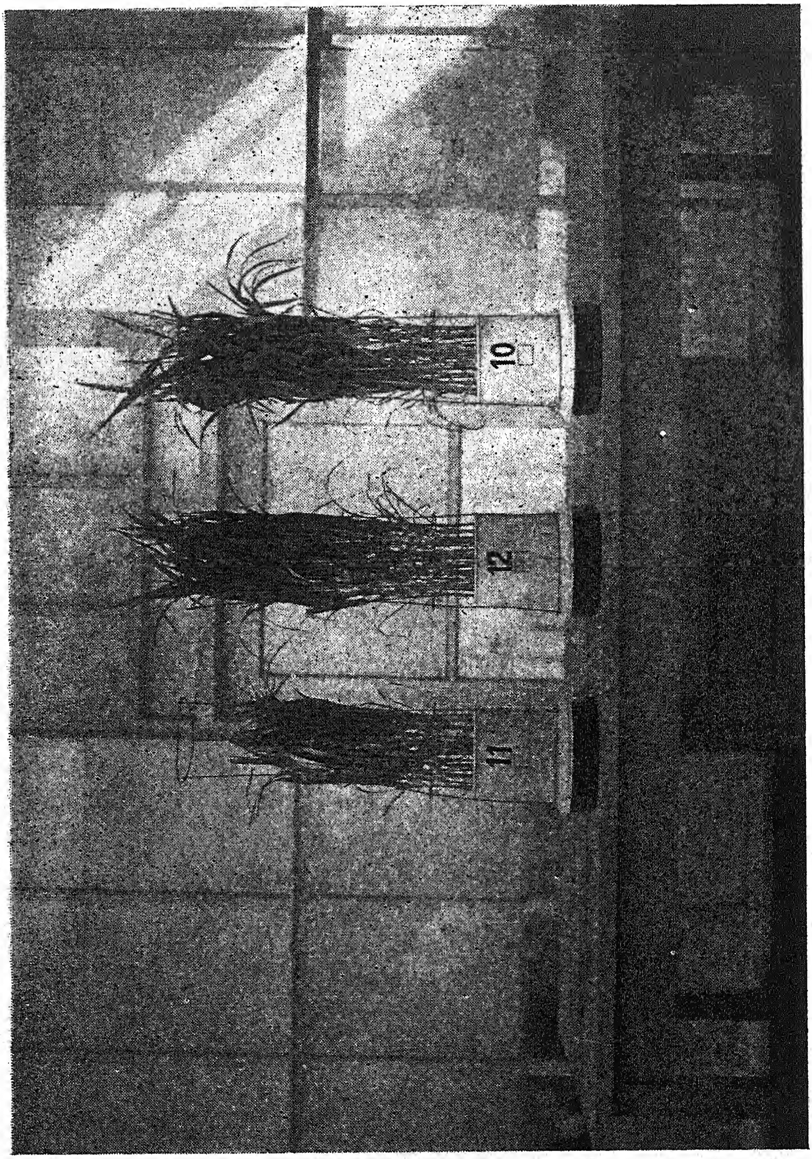


FIG. 5. View, at harvest time, of pots which had received treatments 11, 12 and 10 respectively.

The weighed salts corresponding to each plot were broadcasted uniformly over the whole surface of the plot. The treatments applied are described in Table VI.

Treatments	Cwt. NH_3 per acre	Cwt. P_2O_5 per acre	Cwt. K_2O per acre
A	2.25	2.25	0
B	2.25	2.25	0.75
C	2.25	2.25	1.50
D	2.25	0	2.25
E	2.25	0.75	2.25
F	2.25	1.50	2.25
G	0	2.25	2.25
H	0.75	2.25	2.25
I	1.50	2.25	2.25
J	2.25	2.25	2.25
K	0.75	0.75	0.75
L	1.50	1.50	1.50

Table VI.—Treatments applied in the field experiment.

Fertilizer applications were made on January 10 and 11, 1937. The field was planted several times to Hegari Sorghum in rows 34.8 inches apart, the holes in each row being at distances of 1 foot from the adjacent ones. Three seeds were planted in each hole, there being 6 rows in each plot. Due however to the repeated failures in obtaining the proper germination of the seeds, it was finally decided to plant the field to Sudan grass. The Hegari Sorghum seeds had a very high germination percentage but field 1D was infested with large numbers of ants and as soon as the seed shells were softened, the ants destroyed the seed almost completely. The Sudan grass, planted on May 6, 1937 and replanted on June 6, 1937 in the places where no seeds had germinated, gave a very good stand in all plots. The experimental field was watered almost daily for two or three weeks to insure a good stand. On August 23–4, 1937, the crop in each plot was harvested and weighed. Diagram No. I shows the distribution of the treatments on the experimental field and the yields in pounds per plot.

8-H 104.5	8-C 115.8	8-J 116.4	8-F 114.2	8-G 87.1	8-D 74.3	8-I 105.5	8-B 114.9	8-K 95.4	8-L 100.8	8-A 113.7	8-E 80.7
7-E 95.0	7-K 74.4	7-G 72.2	7-H 86.2	7-C 90.2	7-B 112.3	7-L 89.6	7-F 91.1	7-A 101.0	7-D 56.5	7-J 97.7	7-I 95.5
6-B 103.9	6-F 94.5	6-D 86.0	6-L 102.1	6-I 114.9	6-A 114.5	6-J 114.2	6-G 72.8	6-E 61.6	6-K 67.9	6-H 91.3	6-C 105.4
5-L 88.5	5-A 98.4	5-I 96.1	5-J 113.5	5-E 103.7	5-K 93.5	5-C 116.1	5-D 72.5	5-H 74.1	5-B 95.7	5-F 97.5	5-G 77.4
4-I 118.9	4-E 96.3	4-K 87.7	4-B 115.8	4-H 95.4	4-L 123.1	4-F 125.5	4-J 117.6	4-C 114.7	4-G 93.7	4-D 69.7	4-A 129.1
3-F 102.4	3-J 120.5	3-H 81.2	3-C 99.0	3-A 92.0	3-G 74.9	3-D 87.6	3-K 93.2	3-L 117.2	3-E 118.2	3-I 129.7	3-B 126.6
2-D 91.4	2-G 68.1	2-L 95.2	2-K 71.8	2-J 123.2	2-I 122.4	2-A 124.9	2-E 122.1	2-B 143.2	2-F 119.1	2-C 119.4	2-H 108.9
1-A 115.0	1-B 123.9	1-C 122.1	1-D 104.9	1-E 112.2	1-F 120.1	1-G 86.9	1-H 110.4	1-I 126.5	1-J 130.2	1-K 107.1	1-L 122.5

DIAGRAM NO. I

DISTRIBUTION OF TREATMENTS ON EXPERIMENTAL FIELD
AND
YIELDS IN LBS. PER PLOT

The results of this field experiment have been tabulated in Table VII.

Treatments (in cwt. of substance per acre)				Yields (in pounds of green material per plot)								
				Replications								Average
No.	$NH_{(3)}$	P_2O_5	K_2O	1st	2nd	3rd	4th	5th	6th	7th	8th	
A	2.25	2.25	0	115.0	124.9	92.0	129.1	98.4	114.5	101.0	113.7	111.1
B	2.25	2.25	0.75	123.9	143.2	126.6	115.8	95.7	103.9	112.3	114.9	117.0
C	2.25	2.25	1.50	122.1	119.4	99.0	114.7	116.1	105.4	90.2	115.8	110.3
D	2.25	0	2.25	104.9	91.4	87.6	69.7	72.5	86.0	56.5	74.3	80.4
E	2.25	0.75	2.25	112.2	122.1	118.2	96.3	103.7	61.6	95.0	80.7	98.7
F	2.25	1.50	2.25	120.1	119.1	102.4	125.5	97.5	94.5	91.1	114.2	108.0
G	0	2.25	2.25	86.9	68.1	74.9	93.7	77.4	72.8	72.2	87.1	79.1
H	0.75	2.25	2.25	110.4	108.9	81.2	95.4	74.1	91.3	86.2	104.5	94.0
I	1.50	2.25	2.25	126.5	122.4	129.7	118.9	96.1	114.9	95.5	105.5	113.7
J	2.25	2.25	2.25	130.2	123.2	120.5	117.6	113.5	114.2	97.7	116.4	116.7
K	0.75	0.75	0.75	107.1	71.8	93.2	87.7	93.5	67.9	74.4	95.4	86.4
L	1.50	1.50	1.50	122.5	95.2	117.2	123.1	88.5	102.1	89.6	100.8	104.9

Table VII.—Results of the Field Experiment with Sudan Grass on Vega Baja silty clay.

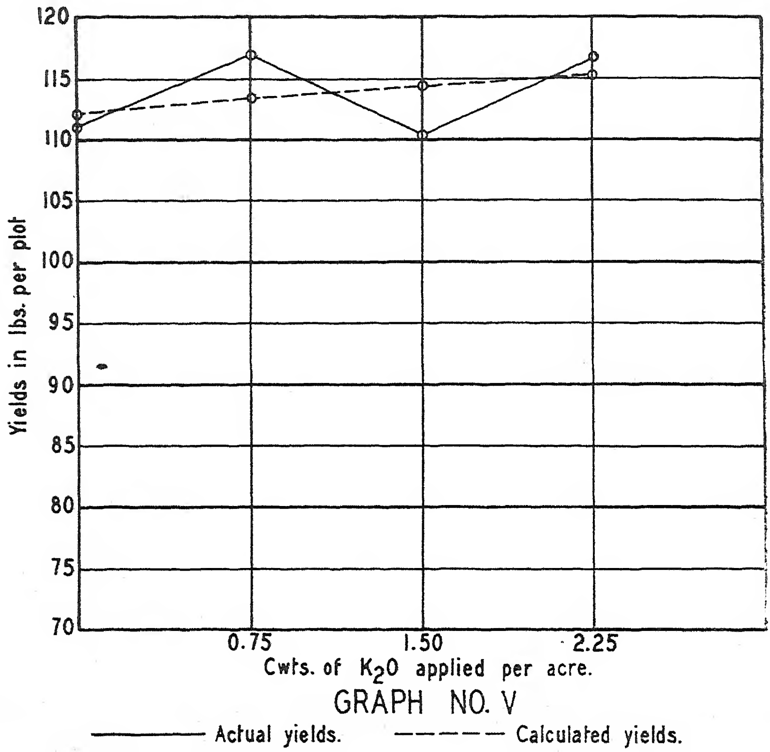
Interpretation of the Results of the Field Experiment: (*a*) The equation of the type of equation (2) which fits best the average results obtained with treatments A, B, C and J is

$$y = 120.0(1 - 0.80518^{12.61 + x}). \tag{8}$$

This means that in this soil there are 12.61 cwts. K_2O per acre in a form as available to the plants as the K_2O in sulphate of potash which was the material used to furnish the K_2O in this experiment. The fit between the actual yields obtained and those calculated by making use of equation (8) may be observed in Table VIII and Graph V.

Cwts. K_2O added per acre	Yields (in pounds of green material per plot)	
	Actual	Calculated
0	111.1	112.2
0.75	117.0	113.4
1.50	110.3	114.4
2.25	116.7	115.2

Table VIII.—Comparison between the average yields obtained with treatments A, B, C and J and those calculated by making use of equation (8).



Graph V.—Comparison between the average yields obtained with treatments A, B, C and J and those calculated by making use of equation (8).

In the pot experiment performed with this same type of soil, it was found that the surface soil of this field contained 0.5163 g. K_2O per kilogram of soil, and if it is assumed that one acre of soil weighs 2,000,000 pounds, then it would contain 1032.6 pounds K_2O per acre. On the basis of this assumption, the field experiment demonstrates a presence of $1261/1032.6 = 1.22$ times the amount of potash determined as available by the pot experiment.

(*b*) The equation of the type of equation (2) which fits best the average results obtained with treatments D, E. F. and J is

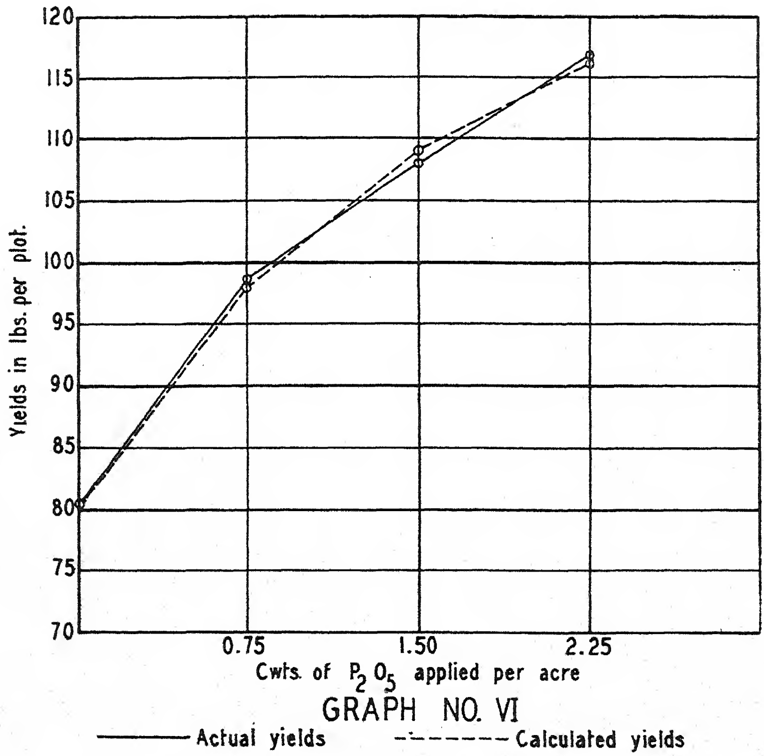
$$y = 129.0(1 - 0.55385^{1.66 + x}). \qquad (9)$$

This means that in this soil there are 1.66 cwts. P_2O_5 per acre in a form as available to the plants as the P_2O_5 in superphosphate of lime which was the material used to furnish the P_2O_5 in this experiment.

The fit between the actual yields obtained and those calculated by making use of equation (9) may be observed in Table IX and Graph VI.

Cwts. P_2O_5 added per acre	Yields (in pounds of green material per plot)	
	Actual	Calculated
0	80.4	80.6
0.75	98.7	97.9
1.50	108.0	109.1
2.25	116.7	116.2

Table IX.—Comparison between the average yields obtained with treatments D, E. F and J and those calculated by making use of equation (9).



Graph VI.—Comparison between the average yields obtained with treatments D, E. F and J and those calculated by making use of equation (9).

In the pot experiment performed with this same type of soil it was found that the surface soil of this field contained 0.0670 g. P_2O_5 per kilogram of soil, and if it is assumed that one acre of soil weighs 2,000,000 pounds, then it would contain 134 pounds P_2O_5 per acre. On the basis of this assumption, the field experiment demonstrates a presence of $166/134 = 1.24$ times the amount of P_2O_5 determined by the pot experiment. This figure compares favorably with the previous one of 1.22 obtained in the case of K_2O as the variable factor. The ratio of the amounts of P_2O_5 and K_2O determined by the pot experiment is practically equal to the ratio of the amounts of P_2O_5 and K_2O determined by the field experiment. This may be considered a good check with regard to the accuracy of this kind of pot experiments.

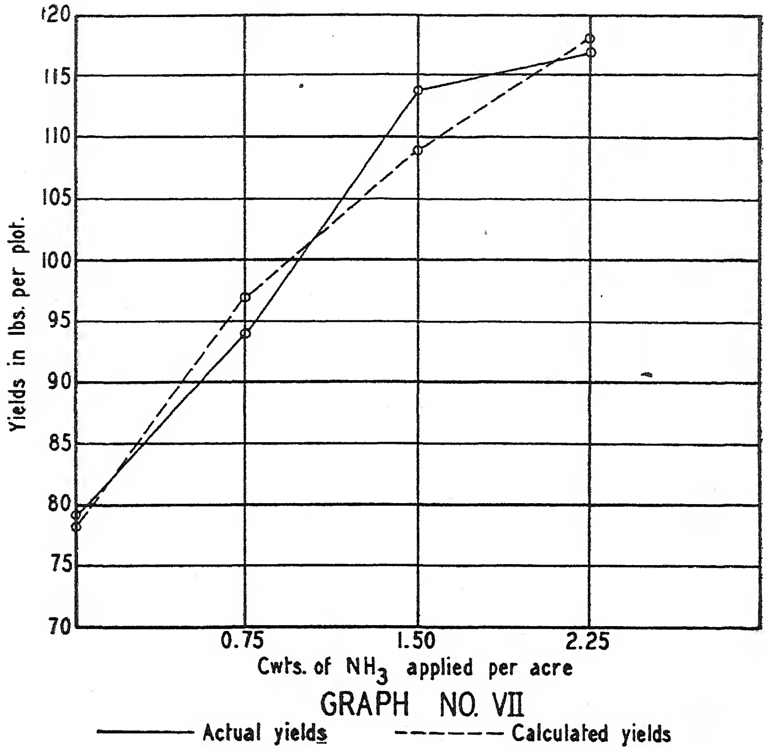
(*c*) The equation of the type of equation (2) which fits best the average results obtained with treatments G, H, I and J is

$$y = 136.6(1 - 0.5968^{1.65 + x}). \tag{10}$$

This means that in this soil there are 1.65 cwts. NH_3 per acre in a form as available to the plants as the NH_3 in sulphate of ammonia which was the material used to furnish the NH_3 in this experiment. The fit between the actual yields obtained and those calculated by making use of equation (10) may be observed in Table X and Graph VII.

Cwts. NH_3 added per acre	Yields (in pounds of green material per plot)	
	Actual	Calculated
0	79.1	78.3
0.75	94.0	97.0
1.50	113.7	109.0
2.25	116.7	117.9

Table X.—Comparison between the average yields obtained with the treatments G, H, I and J and those calculated by making use of equation (10).



Graph VII.—Comparison between the average yields obtained with the treatments G, H, I and J and those calculated by making use of equation (10).

In the pot experiment performed with this same type of soil, it was found that the surface soil of this field contained 0.0706 g. NH_3 per kilogram of soil, and if it is assumed that one acre of soil weighs 2,000,000 pounds, then it would contain 141.2 pounds NH_3 per acre. On the basis of this assumption, the field experiment demonstrates a presence of $165/141.2 = 1.17$ times the amount of NH_3 determined by the pot experiment. This figure is of the same order as the two previous ones found with K_2O and P_2O_5 as nutrients in variable amounts and it seems as if it might be concluded, in the light of this evidence, that pot experiments of this type may be used to determine with fair accuracy the relative available amounts of the three principal nutrients, i. e., nitrogen, phosphoric acid, and potash.

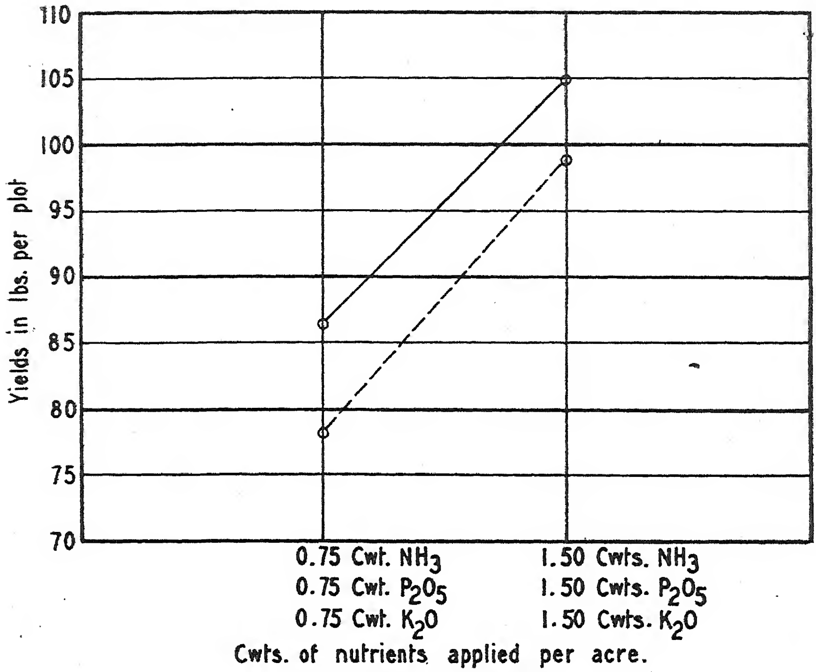
(*d*) If the general equation of the type of equation (6) corresponding to this experiment is calculated from the equations (8), (9) and (10), the following general equation is obtained:

$$y=153.6(1-0.5\ 68^{1.65+x_n})(1-0.55385^{1.66+x_p})(1-0.80518^{12.61+x_k}). \quad (11)$$

Calculating by means of equation (11) the yields which should have been produced by treatments K and L of the field experiment, and comparing these calculated values with the actual yields obtained in said experiment, it will be found that in this case there is a very poor fit between these results. This poor fit may be observed in Table XI and Graph VIII.

Nutrients added per acre	Yields (in pounds of green material per plot)	
	Actual	Calculated
0.75 cwt. NH_3; 0.75 cwt. P_2O_5; 0.75 cwt. K_2O	86.4	78.2
1.50 cwt. NH_3; 1.50 cwt. P_2O_5; 1.50 cwt. K_2O	104.9	98.8

Table XI.—Comparison between the average yields obtained with treatments K and L and those calculated by making use of equation (11).



GRAPH NO. VIII

——— Actual yields. - - - - - Calculated yields.

Graph VIII.—Comparison between the average yields obtained with treatments K and L and those calculated by making use of equation (11).

This behaviour is analogous to the one observed in the case of the pot experiment and it corroborates a conclusion which might have been drawn from those results, in fact, that the general equation calculated for a crop growing in a soil under certain fertilizer concentrations is not applicable to other conditions. This same behaviour was noticed by the late W. J. Spillman on studying the results of a tobacco fertilizer experiment conducted by W. W. Garner and his associates at Georgia. The explanation for these discrepancies offered by Spillman might be accepted for said experiment but in our case, where the conditions claimed to produce those effects were not present, no explanations of this sort are possible to maintain the general applicability of such an equation. If this is so, then, the 4-treatment procedure recommended by Mitcherlich, based on the applicability of this general equation and with fixed values for the effect factors, shonld not give reliable results.

The conclusion arrived at, therefore, is that the 7-treatment tests should be preferred to the 4-treatment ones recommended by Mitscherlich, for although they are more elaborate and costly than the 4-treatment ones, yet their accuracy more than offsets the disadvantages mentioned.

Procedure Followed at Present for the Determinarion of the Nutrient Contents of a Soil by Means of Pot Tests

Partial samples to the desired depth are taken at several places in the field representing the soil type to be studied. These soil samples are air dried, sieved through a 0.25 inch circular hole sieve and well mixed.

The proportion of soil to Corozos sand in the soil-sand mixture to be used in the pot tests is determined from the texture of the soil sample. For example, with clays or silty clays 2 kilos of soil are mixed with 4 kilos of Corozos sand, with sandy loams 4 kilos of soil are mixed with 2 kilos of Corozos sand, etc., to make up the 6 kilos for each pot.

The soil and sand are mixed in an oil cloth with the proper amounts of the salts which are used to furnish the nutritive materials. The following seven treatments are given by quadruplicate to each soil-sand mixture:

1—1.000 g. NH_3; 1.000 g. P_2O_5.
2—1.000 g. NH_3; 1.000 g. P_2O_5; 0.500 g. K_2O.
3—1.000 g. NH_3; 1.000 g. K_2O.
4—1.000 g. NH_3; 0.500 g. P_2O_5; 1.000 g. K_2O.
5—1.000 g. P_2O_5; 1.000 g. K_2O.
6—0.500 g. NH_3; 1.000 g. P_2O_5; 1.000 g. K_2O.
7—1.000 g. NH_3; 1.000 g. P_2O_5; 1.000 g. K_2O.

Of the 28 pots used to study each soil: treatment 1 is given to pots Nos.. 1, 8, 15 and 22; treatment 2 is given to pots Nos. 2, 9, 16 and 23; treatment 3 is given to pots Nos. 3, 10, 17 and 24; treatment 4 is given to pots Nos. 4, 11, 18 and 25; treatment 5 is given to pots Nos. 5, 12, 19 and 26; treatment 6 is given to pots Nos. 6, 13, 20 and 27; and treatment 7 is given to pots Nos. 7, 14, 21 and 28.

Once the soil, sand and salts corresponding to a given pot are well mixed, the whole mixture is transferred to the corresponding Mitscherlich's pot. Each pot is weighed and is then ready to plant.

Immediately before planting, 400 ml. of distilled water are poured on top of the soil of the pot with a sprinkler. With the Hegari Sorghum seeds now available, 40 seeds are planted in each pot with

the idea of leaving 35 plants to grow in each pot. The seeds are half-buried, by using a small forceps. The seeds are distributed uniformly upon the whole surface of the pot. A rapid and easy way to do this distribution is to plant the first 37 seeds in the order illustrated in diagram No. 3, turning the pots around after planting seed No. 22. The other three seeds are planted to fill the largest vacant spaces remaining after the first 37 seeds are planted.

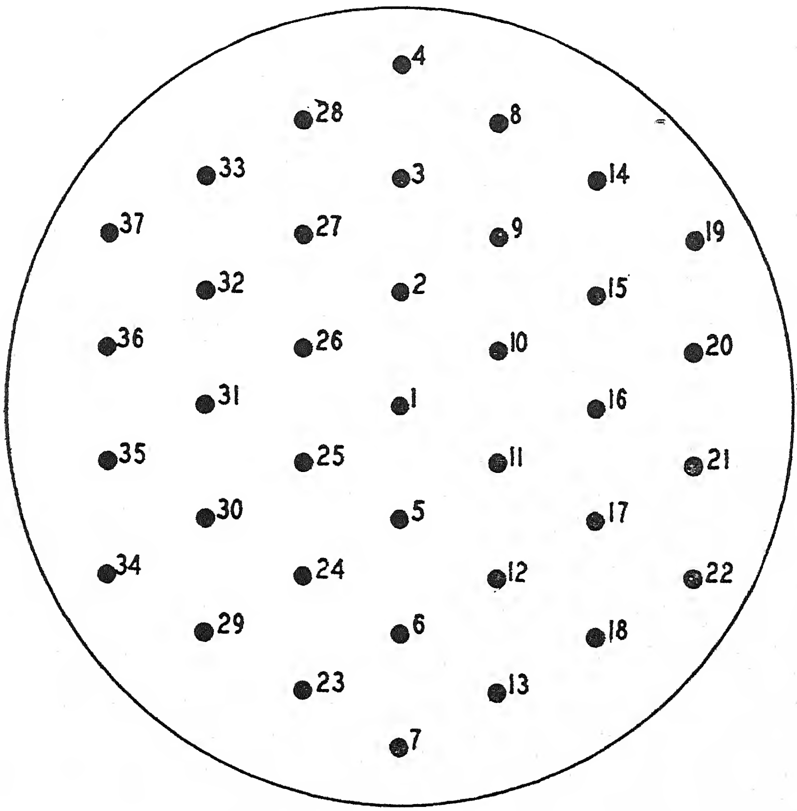


DIAGRAM NO. II

MANNER OF PLANTING SEEDS IN ORDER TO OBTAIN A UNIFORMLY SPACED DISTRIBUTION.

After the 40 seeds have been half-buried, drops of water are allowed to fall over and around the seeds in order to pack the soil against the seeds but leaving their upper part uncovered.

The next day nearly all the seeds will have broken their shells. The seeds which have loosened themselves are half-buried again and the whole surface of the pot is moistened.

This procedure is repeated the next day, by which time the seeds will have sent their first root into the soil and their shoots will be about ½ inch in height.

On the next day most of the plants will have already 2 leaves open and they will be about 1½ inches in length. The ungerminated seeds and as many plants as necessary are removed this day from each pot, leaving 35 plants in each pot. Each pot is brought with distilled water to a weight equal to its dry weight plus 800 g.

In the succeeding days the water content of the pots is raised by increasing the weight of the pots by 200 g. daily at first and then by smaller amounts until full water capacity is attained. The idea is to attain this full water capcity as soon as possible.

After this stage has been reached the first thing in the morning to be done is to see which pots have percolated water to the pan below and which ones have not. The pots which have percolated water are brought with distilled water to the same weight as on the previous day, after pouring on the pot the percolated solution. The pots which have not percolated water are brought to a weight which is 10 g. larger than the corresponding weights of the previous day. However, if after thus increasing the weight of one pot by 10 g. on a day it is found on the next day that no water percolates, the increase in weight on the next day (and succeeding ones if necessary) will be by 20 g. This watering procedure is continued until harvest time; in our case, until the plants are about to head.

At harvest time all the material above the soil in each pot is cut into pieces of about 1 inch in length and placed in a tared wire basket. These baskets are placed on a constant temperature electric oven and kept at a temperature of about 115°C. until constant weight is attained. It is usually found that this condition is attained on allowing the oven to stay lighted overnight.

The baskets are weighed on a torsion balance to the nearest 0.1 gram immediately upon removing from the oven, the procedure being to remove one tray and weigh it before removing the next.

The calculations necessary to do the interpretation of one of these experiments are presented below. This experiment was performed with Río Piedras clay, a very acid type of soil (pH — 4.39) in which a previous experiment done without $CaCO_3$ applications had failed due to the extreme acidity of this soil. For this reason, $CaCO_3$ as a variable factor was also introduced in this experiment, making a

total of 9 treatments instead of the standard number of 7 treatments. The treatments and yields obtained are found in Table XII. In this case 2 kilos of soil were mixed with 4 kilos of Corozos sand.

Treatments		Yields (in grams per plot)				
		Replications				
No.	Nutrients added per pot	1st	2nd	3rd	4th	Average
1	1.000 g. P_2O_5; 1.000 g. K_2O; 6.000 g. $CaCO_3$	19.0	18.2	17.5	17.8	18.125
2	0.500 g. NH_3; 1.000 g. P_2O_5; 1.000 g. K_2O; 6.000 g. $CaCO_3$	34.7	33.6	33.6	33.6	33.875
3	1.000 g. NH_3; 1.000 g. K_2O; 6.000 g. $CaCO_3$	7.1	7.1	7.7	7.2	7.275
4	1.000 g. NH_3; 0.500 g. P_2O_5; 1.000 g. K_2O; 6.000 g. $CaCO_3$	30.5	32.4	29.9	30.0	30.700
5	1.000 g. NH_3; 1.000 g. P_2O_5; 6.000 g. $CaCO_3$	23.3	22.3	19.8	22.9	22.075
6	1.000 g. NH_3; 1.000 g. P_2O_5; 0.500 g. K_2O; 6.000 g. $CaCO_3$	31.8	36.7	34.1	32.2	33.700
7	1.000 g. NH_3; 1.000 g. P_2O_5; 1.000 g. K_2O	6.0	8.1	6.3	5.8	6.550
8	1.000 g. NH_3; 1.000 g. P_2O_5; 1.000 g. K_2O; 3.000 g. $CaCO_3$	30.9	33.6	31.1	31.8	31.850
9	1.000 g. NH_3; 1.000 g. P_2O_5; 1.000 g. K_2O; 6.000 g. $CaCO_3$	34.6	36.0	32.9	35.5	34.750

TABLE XII. Results obtained in a fertilizer pot experiment with Río Piedras clay.

The following formulas, derived from equation (2), are used to simplify the calculation processes:

$$R = \frac{y_3 - y_2}{y_2 - y_1} \qquad (12)$$

$$M = \frac{y_2 - y_1}{R^{x_1} - R^{x_2}} \qquad (13)$$

$$A = y_1 + MR^{x_1} \qquad (14)$$

$$b = \frac{\log M - \log A}{\log R} \qquad (15)$$

To calculate the amount of available NH_3 in the 2 kilos of soil used for the soil-sand mixture, the average yields of treatments 1, 2 and 9 are used. Thus, expressing the NH_3 aplications as units of 0.500 g. NH_3 to simplify the calculations.

$$x_1 = 0; \quad y_1 = 18.125$$
$$x_2 = 1: \quad y_2 = 33.875$$
$$x_3 = 2; \quad y_3 = 34.750$$

Therefore, $R = \dfrac{34.750 - 33.875}{33.875 - 18.125} = \dfrac{0.875}{15.750} = 0.05556$

$$M = \frac{15.750}{1 - 0.0556} = \frac{15.750}{0.944444} = 16.6765$$

$$A = 18.125 + 16.6765 = 34.8$$

$b = \dfrac{1.22210 - 1.54158}{0.74476 - 2} = \dfrac{-0.31948}{-0.25524} = 0.2545$ units or

0.2545(0.500 g. NH_3) = 0.1272 g. NH_3. Therefore, this soil contains 0.1272 g. NH_3 per 2 kilos of soil.

The calculation of the available amounts of the other nutrients is made in a similar way.

Summary and Conclusions

A discussion of the principles underlying the applications of Mitscherlich's equations to the determination of the nutrient contents of a soil and of the objects in view in complying with the requisites of the project under which the described studies were done have been made.

The procedure employed in performing a certain pot experiment with Mitscherlich's pots is described. A detailed interpretation of the results of that experiment has been made.

The procedures used in performing and in the interpretation of the yield data obtained from a field experiment implanted on a field with the same soil type as was used in the pot experiment have been also described. The results of both of these experiments have been compared and the conclusions set further on have been derived from the results obtained in this comparison.

Detailed instructions for making the determination of the nutrient contents of a soil by a modification of Mitscherlich's 4-treatment method are presented.

The following conclusions are derived from the experimental data presented:

1. Mitscherlich's special equation for the relation existing between the initial nutrient concentration of a single nutrient in a soil and the yield of a crop there planted is an accurate and simple one.

2. Such an equation may be used to determine with a high precision the available amount of any nutrient in a given soil.

3. Mitscherlich's general equation relating the yield of a crop with the initial concentrations of the three principal nutrients, (nitrogen, phosphoric acid and potash), does not hold.

4. Mitscherlich's 4-treatment method, based on the applicability of this latter equation, is not accurate under Puerto Rican conditions for the vegetative period of growth of a crop, that is, from the time of planting to the time of heading.

5. A modification of Mitscherlich's method, including 7 treatments and based on the applicability of the Mitscherlich's special equations for variations in the concentrations of each individual nutrient respectively, is described as now used.

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NEW SOUTH AMERICAN SARCOPHAGIDAE (DIPTERA)

By David G. Hall, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C.

The following species of Sarcophagidae are described in order to make the names available for Mr. L. F. Martorell, of the Puerto Rican Experiment Station at Río Piedras, who collected the specimens.

Sarcophaga camura, new species

Figure 1

Male.—Head with front narrow, 0.18 of head width; parafacial and parafrontal silvery pollinose, with a slight yellowish tinge, the former bare; frontal bristles about eight or nine, the rows not widely diverging below, and descending about to the base of the second antennal segment; reclinate fronto-orbital bristles absent; ocellar bristles minute, outer vertical bristles not differentiated; antenna rather yellowish, third segment nearly three times length of second and reaching nearly to vibrissae, which are normal and at oral margin; clypeus long and narrow; epistoma short and hardly narrowed; arista with long plumosity; palpus and proboscis black, both ordinary; bucca short, less than one-fifth eye height, and with both black and pale yellowish-brown hairs before the metacephalic suture; back of head with one row of postocular ciliae and with pale hairs below.

Thorax silvery pollinose, with the normal three to five black stripes; propleura bare; anterior acrostichal bristles absent; anterior dorsocentral bristles two; humeral bristles two; posterior dorsocentral bristles three; sternopleural bristles two; prescutellar bristles present but reduced; laterally and below with long, yellowish-brown hairs; scutellum with three marginal bristles and without preapical or apical bristles.

Abdomen tessellated and with three shifting black stripes; median marginal bristles on both second and third visible segments; fourth visible segment with a marginal row of about 12 bristles; laterally and below with long yellowish-brown hair.

Hypopygium of normal size; first segment black and heavily grayish pollinose; second segment smaller than first, black, with abundant, long, curling, black hairs; genital features as illustrated.

Wing hyaline; costal spine absent; third costal section about as long as fifth; first and fifth veins bare; third vein with some basal setulae; basicosta yellow.

Legs black; fore and middle femora distally and below with some long yellowish-brown hairs; middle tibia with one anterodorsal bristle and some villosity; hind femur and tibia with long villosity.

Female.—Unknown.

Type locality.—"La Providencia", Maracay, Venezuela.

Type and *paratype.*—U. S. National Museum No. 52069.

Remarks.—Described from the type and one male paratype collected November 13, 1932, by Serres and Martorell.

The peculiar elongate yellowish-brown pile or hair on the sternum and venter in this species approaches the condition found in Sarothromyinae. This species runs to *Mehria* End. in Townsend's keys, 1935, Manual of Myiology, *2*, but is not closely related to *Sarcophaga nemoralis* Kr., the genotype of *Mehria*, which is European. I describe it in the genus *Sarcophaga* sens. lat. until additional related material can be studied.

Sarcophaga rimosa, new species

Figure 2

Male.—Head with front very narrow, only 0.14 of head width; one parafrontal only one-third width of frontal stripe; parafrontal and parafacial bright golden pollinose, the pollinosity becoming thinner toward vertex; facio-orbital bristles present in several rows below, near eye; frontal bristles about 14, the rows widely diverging below and extending to about the middle of the second antennal segment; inner vertical bristles present; vibrissae considerably above oral margin and slightly approximated, bucca about one-fourth eye height, with only black hair before the metacephalic suture; back of head with one and a partial second row of postocular ciliae.

Thorax black, with six yellowish, dorsal, longitudinal stripes, two median, two postsuturally extending over the postalar callus, and two extending over the humeri and notopleurae to the postalar callus; a golden pleural stripe extending across the propleura, metapleura, and pteropleura; anterior acrostichal bristles three; posterior acrostichal bristles three or four; anterior dorsocentral bristles three; posterior dorsocentral bristles four; sternopleural bristles three; scutellum black with golden pollen, except for a median longitudinal stripe, with two marginal bristles, one subapical bristle, and one apical bristle.

Abdomen black, tessellated, with four rows of golden pollinose spots, these spots not extending to the posterior margins of the segments; third segment with median marginal bristles; fourth segment with a marginal row of about 12 bristles; fifth sternite reddish-orange, the two arms widely diverging and with long, thin hairs along the inner margins.

Hypopygium of normal size; first segment red; second segment globose, smaller than first, red, with long, curling, black hairs. Genital features as illustrated.

Wing hyaline, third costal section as long as fifth; third vein with several basal setulae.

Legs black; anterior tibia with one posterior bristle at apical third; mid femur with two posterior bristles near apex; mid tibia with one anterodorsal bristle at apical third; hind tibia without long villosity.

Female.—Unknown.

Type locality.—"La Provindencia", Maracay, Venezuela.

Type.—U. S. National Museum No. 52071.

Remarks.—This species appears to some extent like species of *Orobrachycoma* Tns., which differ by having three posterior dorso-central bristles; also like species of *Dexosarcophaga* Tns., which differ by having the hypopygium red and the second segment of the abdomen with median marginal bristles.

Abacantha, new genus

Male.—Head without parafacio-orbital bristles; frontal bristles about seven, the rows hardly divergent below; one proclinate fronto-orbital bristle and one reclinate fronto-orbital bristle; outer vertical bristle distinct; third antennal segment fully four times as long as second and reaching almost to the vibrissae, which are normal and at the oral margin; bucca short, less than one-fourth eye height.

Thorax without anterior acrostichal bristles; posterior dorso-central bristles two; sternopleural bristles three; prescutellar acrostichal bristles present.

Abdomen with median marginal bristles on the third segment.

Wing hyaline; first vein setulose.

Legs: Mid femur with comb; hind tibia without villosity.

Genotype.—*Abacantha zygox*, new species.

Abacantha zygox, new species

Figure 3

Male.—Head with front 0.29 of head width; parafrontals and parafacials golden pollinose; antenna black; palpus and proboscis black, both ordinary; bucca with only black hair before the metacephalic suture; back of head with two rows of postocular ciliae, around the middle and below with but pale hair.

Thorax silvery-gray pollinose, with the normal three to five black stripes; scutellum with three marginal bristles and one apical bristle.

Abdomen tessellated and with three shifting black stripes; fourth segment black to apex and with a marginal row of about 12 bristles. Fifth sternite yellow-orange, the inside margins of the two divergent arms covered with soft yellowish pile.

Hypopygium with the first segment red, darker at base and without the customary row of marginal setae; second segment red, small, retracted. Genital features as illustrated.

Wing without costal spine, third costal segment about as long as fifth; third vein with some basal setulae.

Legs black, mid tibia with one anterodorsal bristle.

Type locality.—"La Providencia", Maracay, Venezuela.

Type and *paratype.*—U. S. National Museum No. 52072.

Remarks.—Described from the holotype male, collected by Martorell, and one paratype male collected at San Mateo, Costa Rica, by Pablo Schild, dates unknown.

This species appears close to species belonging to *Notochaeta* Aldrich, having but two posterior dorsocentral bristles. The setulose first vein is suggestive of *Micronotochaeta* Townsend but the head shape of this genus is different. I have not seen specimens of *Anaravinia* Tns., but this genus lacks the ctenidium on the mid femur. *Catheronychia* Tns. is composed of much smaller species, all of which have three posterior dorsocentral bristles.

Tripanurga albicans (Wiedemann)

Figure 4

Sarcophaga albicans Wied., 1830, Auss. Zweifl. *2,* p. 363.
Tripanurga albicans (Wied.), Br. & Berg. 1891, Zweifl. Kais. Mus. *5,* p. 363.

The following description is given to supplement the inadequate descriptions published heretofore.

Male.—Head with front 0.3 of head width; parafrontals and parafacials silvery-gray pollinose, the latter with a row of facio-orbitals below near eye; frontal bristles about six, the rows slightly converging below and reaching to the antennal insertion; proclinate fronto-orbital bristles one; reclinate fronto-orbital bristles one; outer vertical bristles present; antenna black, third segment at least three times as long as the second and reaching almost to the vibrissae, which are normal and at the oral margin; aristal plumosity normal; palpus and proboscis black, both ordinary; bucca one-third the eye height and with only black hair before the metacephalic suture; back of head with one defined row of post-ocular ciliae, around the middle and below with some pale hair.

Thorax silvery-gray pollinose and with the normal three to five black stripes; anterior acrostichal bristles absent; anterior dorso-central bristles two; posterior dorso-central bristles four; sternopleural bristles two; prescutellar acrostichal bristles present; scutellum with two marginal bristles and one preapical bristle.

Abdomen tessellated and with three shifting black stripes; median marginal bristles on the third segment only; fourth segment with a marginal row of about 10 bristles. The posterior part of the abdomen is enlarged and deepened for the reception of the large hypopygium.

Hypopygium with the first segment black, dusted with gray pollen and with a marginal row of about 10 setae; second segment smaller, black, with whitish pollen. Genital features as illustrated.

Wing hyaline; third costal segment as long as fifth, third vein with several setulae at base; first vein setulose.

Legs black; middle tibia with two anterodorsal bristles.

Female.—With two proclinate fronto-orbital bristles and the abdomen of normal shape and depth, otherwise as in male except for normal sexual differences.

Remarks.—The type locality of this species is Brazil, and all of the previous material I have seen has been Brazilian. It is therefore interesting that Serres and Martorell collected one male and one female of the species on November 13, 1932, at "La Providencia", Maracay, Venezuela.

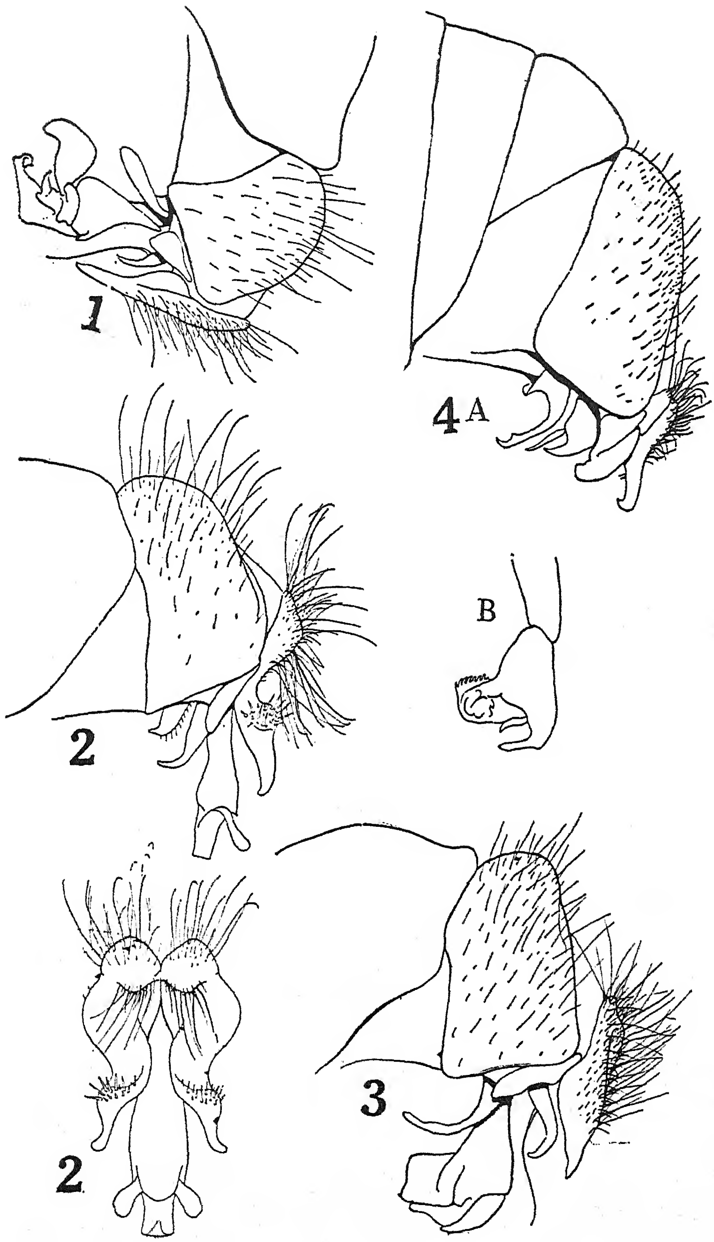
Explanation of Figures

Fig. 1.—*Sarcophaga camura*, n. sp., Left lateral view of male terminalia.

Fig. 2.—*Sarcophaga rimosa*, n. sp., Left lateral view of male terminalia, and rear view of male penis and forceps.

Fig. 3.—*Abacantha zygox*, n. sp., Left lateral view of male terminalia.

Fig. 4.—*Tripanurga albicans* (Wied.). A.—Left lateral view of male terminalia, B.—Penis from same view.



1

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ANTILLEAN ASCALAPHIDAE

By NATHAN BANKS
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Recently Dr. G. N. Wolcott of Puerto Rico sent me a pair of a small Ascalaphid taken in the southwestern part of the island. This has included me to go over the material in the Museum collection, to straighten out certain points in Van der Weele's Revision and in Prof. R. C. Smith's paper on the Haitian species. We have here the types of Burmeister's *senex* and of Hagen's *avunculus*.

Burmeister had two specimens, one from Cuba, one from Savannah, Georgia; these are the same species, and I find no differences between Cuban and United States material but with greater differences between various specimens in the United States. Thus Van der Weele's subspecies, *hageni*, becomes a synonym of *senex*.

Van der Weele, having seen a specimen in the Berlin Museum labeled "*avunculus*", surmised that it might be a Hagen type, and said the antennae were no longer than usual in *senex*, and that Hagen had made a mistake, and put *avunculus* as a synonym of *senex*. The two types of *avunculus* are here, both males, and with the antennae over thirty millimeters long, so distinct from *senex*. Prof. Smith listed from Haiti several species, which to me are only specimens of *sancti-domingi* in varying conditions. But one of them is so different I shall describe it as new.

Of the species *macleayana*, that Guilding described from St. Vincent, I have seen no specimens, and the photograph shows little, if anything, to separate it from *sancti-luciae* Weele.

The species in the collection can be tabulated as follows:

1. Hair on lower face dark; stigma never dark; large species---------------- 2
   Hair on lower face white or almost so---------------------------------- 3
2. In hind wing behind the bend of the first anal the wing is so swollen that the network of cross veins extends past the bend toward the base of wing; four cross veins before radial sector in fore wing---*villosus (ampla)*
   In hind wing the network is interrupted behind the bend of the first anal, the wing being more narrow; three cross-veins before radial sector in fore wings--*walkeri*
3. Antennae of male over 30 millimeters long, much longer than wings; femora as well as tibia very pale--------------------------------*avunculus*
   Antennae of male not 30 millimeters long------------------------------ 4
4. Stigma in both wings plainly dark (except in teneral specimens); femora rather evenly dark; hair on front of mesonotum normally dark-------- 7

Stigma in both wings very pale or yellow; small species................ 5

5. Mid and hind femora pale, but with dark apical band; white hair on front of mesonotum; much white hair in tuft at base of antennae; stigma yellow ....*smithi*

Hair on mesonotum plainly dark, mid and hind femora more evenly dark.. 6

6. Male with a dark spot by stigma of fore wing, female with spot in hind wing ....*opposita*

Male without dark spot in fore wing; vertex a little more narrow....*banksi*

7. In fore wings the tip slightly more acute; stigma usually covering four veinlets, longer than high.. 8

In fore wings the tip rounded; stigma shorter, usually higrer than long ....*sancti-domingi*

8. From Cuba and Bahamas; venation of apical part of wing denser, between the third and fourth branches of the radial sector nine to twelve or or more cells..*senex*

From St. Lucia; venation less dense, between the third and fourth branches of the radial sector eight or less cells............................*sancti-lucia*

Ululodes villosus Pal. de Beauv.

The *U. ampla* McLach is considered a synonym of this by Van der Weele, and doubtless correctly, as there is probably not another species so large from San Domingo. The Museum has ten specimens from Samana Bay. Its large size and tinted wings readily separate it from all other except *U. walkeri.*

Ululodes walkeri Weele

Separated from *U. villosus* by the narrower wings, especially the hind pair, and darker hair on head. In the collection is one specimen from Poey, wholly pale-winged, and a very dark-winged specimen from the coast below Pico Turquino, 26 to 30 June (Darlington). The tips of hind wings are almost black. It was described from Jamaica.

Ululodes senex Burm.

The two types (both females) are here; I can see no difference between them that is not found in greater degree in U. S. and Cuban specimens. It is common in Central and Western Cuba. Both male and female sometimes have a dark spot near stigma in hind wing; in some specimens the whole wing is suffused with yellowish brown. In two specimens (Hope, Arkansas and Dallas, Texas) there are four cross-veins before radial sector in the front wing of one side; in one (San Antonio, Texas) there are four in both front wings and tw o in each hind wing. The hair of the antennal tuft is white in front.

Ululodes avunculus Hag.

The two types (both males) are here; the antennae are over 30 mm. long, much longer than wings; both are from Poey, no definite locality; there is also another Poey male, collected later, and in 1936 Darlington took a male on the south side of Pico Turquino, Oriente, Cuba, 11 June, at 3 to 5,000 feet. I am not sure of the female; there is a female bearing the same number as Poey's third specimen; it is very similar to *senex*. The species is probably confined to Eastern Cuba.

Ululodes sancti-domingi Weele

This species is extremely close to *U. senex*, and shows the same color variations, sometimes a dark cloud in apex of hind wing, sometimes the whole wing tinted with yellowish brown. About the only character to distinguish it is the shorter stigma; the tip of wings is more rounded than in *senex*, but the difference is slight.

What Prof. R. C. Smith listed as *U. villosus* and as *U venezolensis* are this species; while the form called *U subvertens* is different and I described it as new—*U. smithi*.

Ululodes sancti-luciae Weele

Of this I have but one specimen from St. Lucia. It was described from one male from St. Lucia; had it been from Cuba I think it would be put with *U. senex;* the venation is less dense than in *senex* but not strikingly so.

Ululodes smithi sp. nov.

Face mostly dark; hair on lower part white, that at base of antennae largely white, but dark behind; hair on pronotum white, on front of mesonotum also white, above on mesonotum pale gray. Abdomen (♀) pale, with many black lines on sides, and above on several segments a median dark line, and on each side the elongate triangular mark as usual, with a small spot before it; apical segment largely pale, a median black stripe, and on each side a dark spot on the hind margin; legs pale, but mid and hind femora darkened toward tip, and the tibia within dark, tarsus mostly dark.

Wings hyaline, veins mostly dark, stigma in both wings plainly yellowish; in hind wings of female a dark spot behind stigma. Venation and shape of wing much as in *sancti-domingi,* apical field rather evenly three-celled; size of *sancti-domingi*.

From Port-au-Prince, Haiti, 23 Aug. (Smith). Type M.C.Z. No. 23192.

This was treated by Smith (Hayti Neuroptera) as *subvertens* Walk., a South American species with broader wings, hardly any

white in antenal tuft, etc. A male from the same locality has the antennal tuft darker and darker hair on mesonotum, and may belong to this species.

Ululodes opposita sp. nov.

Face mostly dark, hair on lower part white, the tuft at base on antennae with a little white in front, but mostly dark; antennae pale, with dark apical ring on each joint, tip brown; hair on the pronotum white, that on mesonotum dark gray to brown; pleura with long white hair. Legs pale, the hind femora rather evenly brown; abdomen of male dull black, above with a velvety stripe, broader in front, on each side of segments two, three, and four, between these marks is a median pollinose stripe; hair black, except toward base beneath where it is white; abdomen of female mostly black, above on second, third, and fourth segments mostly pale, with black lines, last segments above mostly black, with a pale median line on apical half.

Wings hyaline; veins mostly dark; stigma, in both wings, pale yellowish, over four veinlets, a little longer than high; tips of wings rounded; venation rather open, apical field with three or four rows of cells; in female a large black spot behind and beyond stigma in hind wings; in male with a more rounded black spot beyond stigma in the fore wings.

Length of fore wing, male, 22 mm., width 6 mm.

Length of fore wing, female, 23 mm., width 6.8 mm.

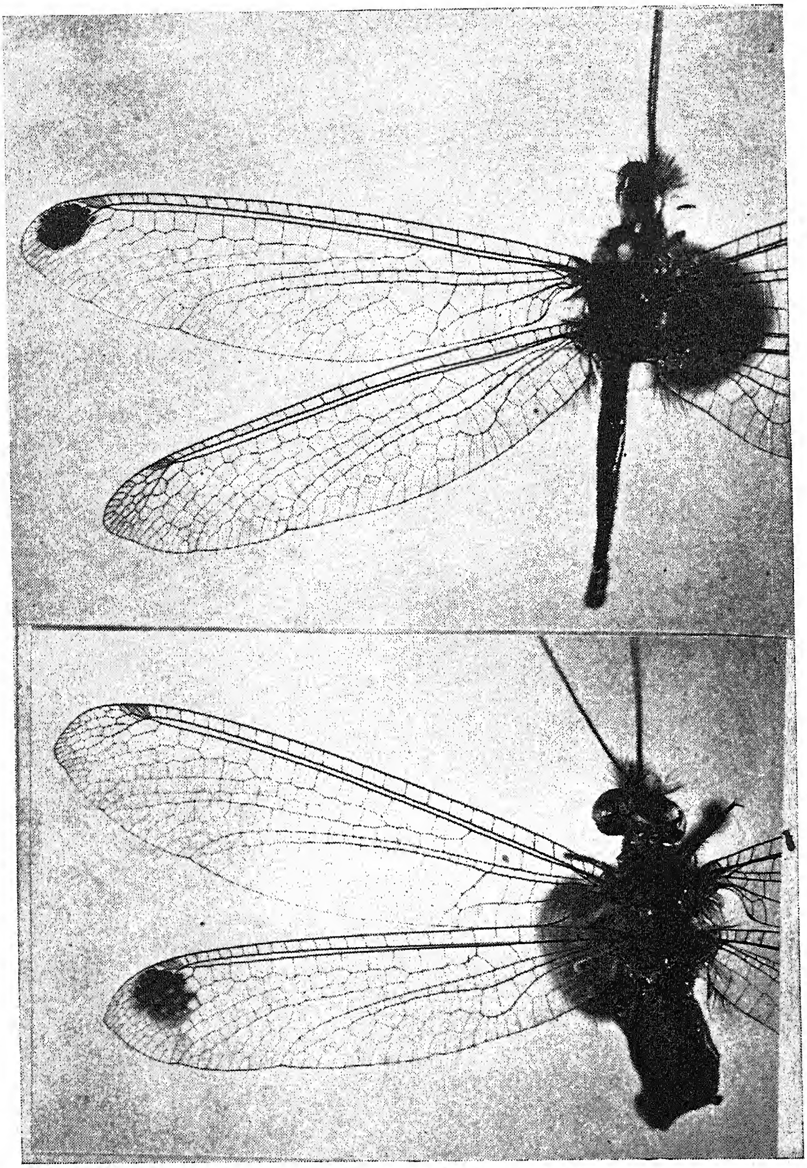
Length of antenna, male 21 mm., of female 22 mm.

From Cabo Rojo, Puerto Rico, near lighthouse, 4 November. G. N. Wolcott and L. P. Martorell. Type M.C.Z. No. 23193.

Unique in the genus in having a black spot in the fore wings.

Ululodes banksi Weele

Of this Jamaican species we have but one specimen; Kingston, 29 Aug. (Darlington). It is very similar to *U. opposita,* except that the male has no black spot in apex of fore wing. It is a little smaller, and the wings more narrow.



EUXESTA STIGMATIAS LOEW, AN OTITID FLY INFESTING EAR CORN IN PUERTO RICO

By Bernard A. App, Bureau of Entomology and Plant Quarentine, U. S. Department of Agriculture.

This paper reports the results of observations made on the otitid fly *Euxesta stigmatias* Loew in connection with investigations on insects attacking corn in Puerto Rico under special funds provided to the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture. The studies were conducted in cooperation with the Experiment Station of the U. S. Department of Agricutulre at Mayagüez, P. R., where laboratory and other facilities were provided for the work. The Isabela Substation of the Agricultural Experiment Station of the University of Puerto Rico, Río Piedras, also cooperated in supplying plots for some of the experiments. Acknowledgement is also made of the advice and assistance rendered by various members of the Station staff. The observations were made from August 1935 to June 1936.

When these studies were begun, corn ears were found infested with dipterous maggots, which caused a very unsightly and malodorous condition, spoiling many ears for market as roasting ears. It was at first thought that the high humidity and heat prevailing in Puerto Rico had caused the silks to rot and that the maggots were feeding on this decaying material. The large number of ears to infested, however, seamed to indicate that these maggots were inflicting primary injury to corn. Further examination disclosed many whitish, elongate eggs deposited on fresh silks near the juncture with the husks. Some of these eggs, together with maggots from infested ears, were taken to the laboratory and reared to maturity on fresh corn silks, and were thus found to repesent the same species. Samples of both lots were sent to Washington, where they were determined as the otitid fly *Euxesta stigmatias* Loew (fig. 1).

Distribution

This fly seems to be generally distributed throughout the tropical part of the Western Hemisphere. Records of the U. S. National Museum show it to be reported from the following locations:

West Indies: Puerto Rico, Cuba, Dominican Republic, Nassau, Virgin Islands.

British West Indies: Barbados, Dominica, St. Vincent, Jamaica.

Central America: Canal Zone, Panama.

South America: Brazil, Bolivia, Paraguay, Perú.

North America: Mexico, Florida.

According to these records the fly has been taken on sugarcane, guava, corn, *Eugenia* spp., orange, and the stem of banana.

ABUNDANCE

No field of corn in the ear stage was examined in which this maggot was not present, and usually infesting a large majority of the ears. The percentage of infested ears seems dependent on the stage of maturity of the corn. The ears usually become infested when they are one to two weeks past silking, but as the corn matures the maggots leave the ears to pupate. Table I gives the percentage of infested ears in some fields examined throughout the period of observation. Field counts were made nearly every month and showed the fly to be present at all seasons.

TABLE I—PERCENTAGE OF CORN EARS INFESTED WITH MAGGOTS OF *EUXESTA STIGMATIAS* IN DIFFERENT FIELDS EXAMINED IN PUERTO RICO

Date of Examination	Locality	Infested Ears Percent
1935		
September 3	Isabela	67.0
October 14	Isabela	31.0
November 6	Isabela	28.0
December 16	Las Mesas (Mayagüez)	30.0
1936		
January 8	Lajas	68.0
February 3	Mayagüez	92.9
May 11	Isabela	97.0
June 1	Mayagüez	96.0
June 5	Isabela	92.0

DAMAGE

There is little exterior evidence of the infestation, as the silks usually dry in the normal manner. Examination of an infested ear reveals that inside the husks, from the tip where the eggs hatched, the silks are rotted down to the grain. The kernels on the tip of the ear are only hollow shells, the maggot having consumed their entire contents. The maggots work between the rows of grain near the cob, they enter the kernal at the bottom, consuming its contents and leaving a hollow shell, and then attack the next kernel. In most

cases only a few kernels at the tip are destroyed, but many ears were infested with maggots in their entire length. Frequently maggots were working in the pith of the ear, which resulted in a stunted, soft ear bearing grain of little value, when any was produced. In field corn most of the maggots had pupated by the time it was ready to harvest. A mold seems to follow the feeding of these maggots, making it impossible to leave seed ears in the field until fully mature. Perhaps the greatest damage caused by this insect is the reduction of the market value of roasting ears by the unsightly and malodorous condition imparted to them.

Life History and Description of Stages

Eggs.—The minute, elongate, whitish eggs (fig. 2) are laid just below the tips of the husks, and usually in strings fastened end to end. During oviposition the female stands on the ear and curves her ovipositor down below the tip of the husk. Some eggs are laid as soon as the silks appear, and as the silks grow out the eggs are pushed out with them and remain attached to them. More often, however, the eggs are laid after the silks have grown out, and they remain just below the tip of the husk until they hatch. Of 200 plants examined during December 1935, 191 were observed to produce silk, and of this number 189, or 98.9 percent, were infested with eggs of this otitid. On this group of plants the silks became infested with eggs on an average of 1.12 days after they appeared. The number of eggs laid on one ear ranged from a few dozen to several hundred. Some of the eggs are lost as the silks grow out, but six ears brought into the laboratory were found to contain 558, 685, 47, 146, 431, and 248 eggs, respectively, or an average of 352.5 eggs per ear. The length of the egg stage is from two to four days. In the fall of 1935 a sample of eggs began hatching on the second day after deposition and completed hatching by the fourth day. On June 18, 1936, some eggs laid the previous day were brought into the laboratory, where they began hatching on June 21 and completed hatching by June 22.

Larvae.—The larvae are also minute and white in color, with darker spiracles and mouth parts. They begin feeding on the fresh silks and work down to the developing grain. When full grown (fig. 3), they are about three-eighths of an inch long. One ear may contain a few to several hundred maggots. Five ears brought into the laboratory were found to contain 545, 113, 108, 106, and 199

larvae, respectively, or an average of 214.2 per ear. Of 200 plants examined daily in the fall of 1935, 191 were observed to silk and 188, or 98.0 percent, because infested. The average length of the larval stage, based on to samples, was 7.46 days (table 2).

The Pupae.—The pupal stage of the fly is passed in a small, brown puparium about one-eighth of an inch in length (fig. 4). In the early stages it is light brown in color, but a it grows older it changes to a dark brown. Before pupation the maggots leave their feeding places and migrate to drier locations. In the laboratory they readily pupated in moist sand, into which they burrowed to the depth of about one-fourth of an inch. Some puparia were found on the tips of the ears among the dry silks, but as only a few were found it is probable that most of the maggots pupate in the soil. The average length of the pupal stage was 7.38 days, on the basis of ten samples reared to maturity.

TABLE 2—DURATION OF LARVAL AND PUPAL STAGES OF *EUXESTA STIMATIAS*, MAYAGÜEZ, P. R., 1935–36

Sample	Larval stage		Pupal stage	
	Individuals	Mean duration	Individuals	Mean duration
	Number	Days	Number	Days
1	19	7.42	19	7.74
2	7	7.00	7	7.14
3	8	7.50	7	7.64
4	12	6.58	12	8.09
5	13	7.31	11	7.14
6	13	7.46	10	7.74
7	17	9.06	12	6.52
8	15	7.07	13	7.70
9	18	7.33	11	7.12
10	8	7.88	5	6.92
Total or average	130	7.46	107	7.38

Adults.—The adult is a small fly of a dark metallic green color with reddish eyes and wings banded with black (fig. 1). The wings are constantly in motion even when the insect is otherwise at rest. The adults are very abundant in cornfields, where they seem to cluster about the parts of the plant that are likely to be moist, such as the tassel and the silks. They were observed ovipositing on the larvas of young coun, but no larvae seemed to come from these eggs. As many as five females have been observed ovipositing on the same ear at the same time.

Control

No attempt was made to control the larvae of this insect in the investigations carried on in Puerto Rico in 1935 and 1936. The protected location of the eggs and the habits of the young maggots in entering the ears after hatching would make control rather difficult. However, some of the experimental control measures used against the corn ear worm (*Heliothis obsoleta* F.) were found to reduce the number of ears infested with *Euxesta* maggots. The results are shown in table 3.

Because most of the eggs are laid below the tips of the husks and the maggots feed inside the husks, poisoning with insecticides was difficult. All the insecticides tested, however, reduced the infestation in some degree, and they all gave better results in the tests completed in June than in those completed in February. This is, no doubt, due to the fact that the fall applications of dust to the silks were delayed until approximately 50 percent of plants had silk, whereas the spring applications were begun soon after the first silk was observed and continued until silks were dry.

Several hand methods of control also reduced the number of infested ears. Cutting the silks and squeezing the tips of the ears had little effect on the larvae. When the silks were cut the field deposited numerous eggs on the cut tips. Those methods that covered the ear or constricted the husk gave better results than other methods. A paper tip consisted of a piece of brown wrapping paper rolled around the tip of the ear and tied securely with string. These tips were applied soon after the plants silked. The wires, hog rings, and strings were also applied as soon as possible without interfering with pollination. The effect of wires and hog rings was about the same as that of the paper tips, but the strings gave poorer results.

TABLE 2—EFFECT ON *EUXESTA STIGMATIAS* OF VARIOUS METHODS USED TO CONTROL THE CORN EAR WORM

Method	Test at Mayagüez Completed February 3, 1936			Tests at Mayagüez Completed June 1, 1936			Tests at Isabela Completed June 5, 1936		
	Number of ears	Percent infested	Percent control	Number of ears	Percent infested	Percent control	Number of ears	Percent infested	Percent control
Hog rings	224	63.92	28.93	342	55.32	40.67	523	46.96	45.07
Paper tips	127	67.99	24.86	304	55.19	40.80	518	46.88	45.15
Wires	172	62.47	30.38	....	....	....	490	51.24	40.79
Strings	163	75.62	17.23	....	....	....	518	61.29	30.74
Cut silks	201	90.95	1.90	338	75.33	20.66	528	82.81	9.22
Squeezing tips	198	90.47	2.38	336	86.29	9.70	514	83.53	8.50
Barium fluosilicate and talc (1:1)	161	82.16	10.69	361	66.17	29.82	542	64.73	27.30
Magnesium arsenate and talc (8:2)	193	79.52	13.33	339	78.63	17.36	546	68.51	23.52
Derris and talc*	186	89.21	3.64	357	83.64	12.35	533	70.86	21.17
Lead arsenate and talc (8:2)	209	75.22	17.63	354	71.65	24.34	538	69.06	22.97
Check	223	92.85	....	321	95.99	....	552	92.03	....

* In the tests completed February 3 a derris and talc mixture of 0.75 percent rotenone content was used; in the later teste the rotenone contest was 1 percent.

Summary

The otitid fly *Euxesta stigmatias* Loew is a serious pest of corn, especially roasting ears for market purposes, in Puerto Rico. The maggots have been observed in all sections of the island and at all seasons of the year. The pest at present seems to be restricted to a tropical habitat, so far as collection records of this insect are known. In most fields examined a large percentage of the ears were infested, and many entire ears were destroyed. Under laboratory conditions the fly was reared from egg to adult in as few as 18 days; so there are many generations during a year.

Although no special studies were made on control, in some experiments in control of the corn ear worm there was a reduction in the number of ears infested with maggots of *Euxesta stigmatias*, which suggests that some of these measures may also be useful in controlling this pest.

Explanation of Plates

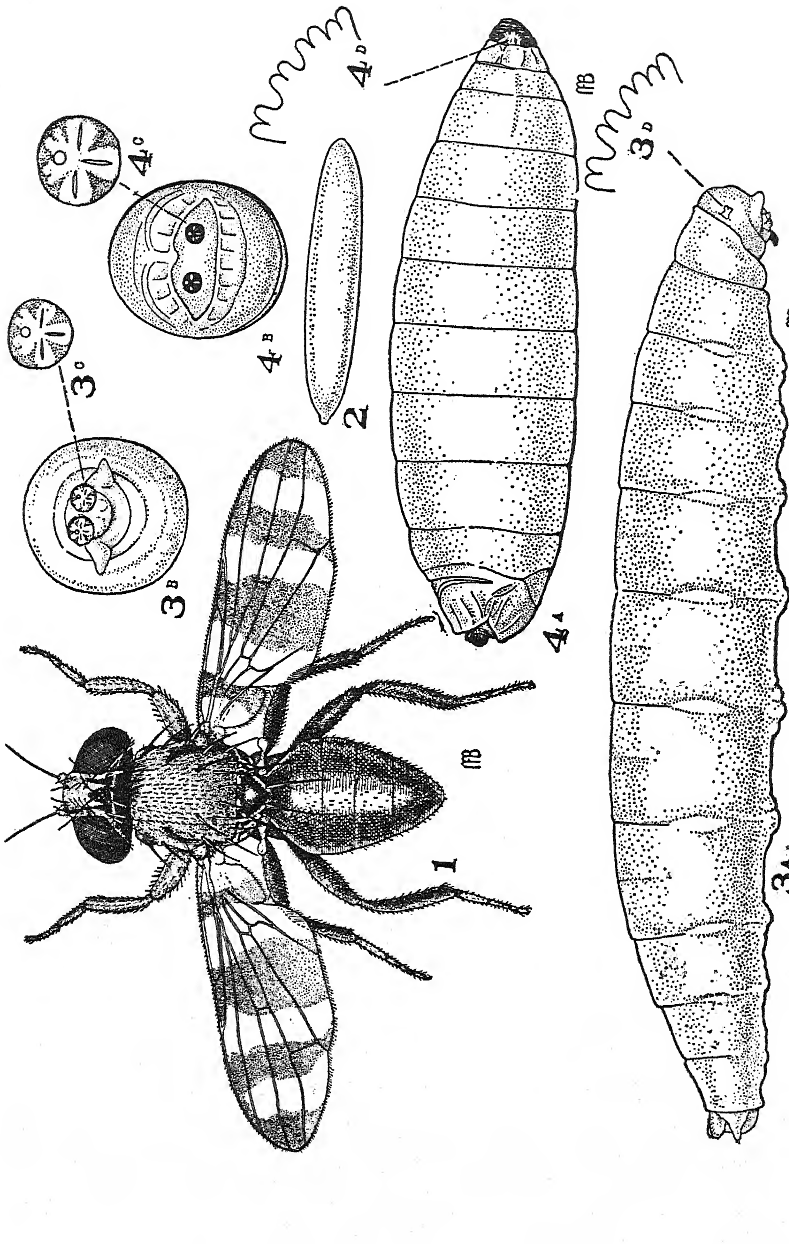
Fig. 1.—Adult of *Euxesta stigmatias* Loew, the larvae of which cause damage to roasting ears in Puerto Rico.

Fig. 2.—Egg of *Euxesta stigmatias*.

Fig. 3A.—Larva of *Euxesta stigmatias*, lateral view. B—Posterior view. C—Posterior spiracle. D—Anterior spiracle.

Fig. 4A.—Puparium of *Euxesta stigmatias*, lateral view. B—Posterior view. C—Posterior spiracle. D—Anterior spiracle.

PLATE X



DESCRIPTION AND BIOLOGIC NOTES ON A *TIPHIA* (HYMENOPTERA: SCOLIIDAE) FROM HAITI

By GEORGE N. WOLCOTT, *Entomologist,*
Agricultural Experiment Station, Río Piedras, P. R.

The normal scarcity of white grubs in cultivated fields in Haiti seemed most remarkable to one accustomed to their former great abundance in Puerto Rico. To be sure, the introduction of the giant Surinam toad, *Bufo marinus* L., into Puerto Rico from Barbados and Jamaica, and its rapid increase in numbers, largely feeding on May beetles (which are the adults of white grubs), has recently so greatly reduced the numbers of white grubs to be found in the cane fields of Puerto Rican lowlands (**3**) that conditions in the two countries now appear substantially similar. But until a few months ago, no introduced Surinam toad was present in Haiti, and the native toad of Haiti, *Bufo gutturosus* Latreille, was no more noticeably abundant than the comparable native toad of Puerto Rico, *Bufo lemur* Cope. The little burrowing owl, *Speyotyto cunicularia troglodytes* Wetmore & Swales, quite abundant in Hispaniola, but not present in Puerto Rico, may be a considerable factor in reducing the number of May beetles, altho the only stomach contents record gives no indication that the owl eats this particular kind of beetle (**2**). Indeed, the most obvious factor in white grub control in Haiti is the abundance of the parasitic wasps belonging to the genus *Tiphia*.

In all the years that numerous entomologists have been collecting insects since the time of Stahl and Gundlach, only four specimens of *Tiphia,* all of which now repose in the U. S. National Museum, have been collected in Puerto Rico. In Haiti, on the contrary, several individual collections of adults of both sexes were made by the writer from time to time at various localities in the lowlands, and the number to be seen at Kenscoff the first time it was visited was so large that the actual number of specimens collected can hardly give a correct impression of the abundance of *Tiphia*. Subsequent visits only served to confirm this preliminary observation of its abundance in the mountains of Haiti. While the wasps occur on various plants, and feeding at various flowers, they greatly prefer those of the wild parsnip, *Pastinaca sativa* L., or the minute droplets of honey dew to be found on sooty mold blackened leaves of guava

bushes infested with the green scale, *Coccus viridis* Green. They are to be noted feeding only in the bright sunshine, and appear to be more abundant and larger in size at the higher altitudes, specifically at Kenscoff (elevation 1,450 meters) up to the pass on the old trail to Furcy. The records of former collections, copied from specimens and the accession cards of the Division of Entomology at Damien, are as follows:

FEMALES

Haiti Acc. No.	Locality	Date	Host	Collector	Number of Specimens
58-27	Mt. Puilsboreau	May 28, 1927	Wild carrot	GNW	1
	Post Chaubert, Le Trou	Nov. 10, 1927		GNW	1
	Kenscoff	Nov. 23, 1927	*Pastinaca*	GNW	2
	Kenscoff	Jan. 5, 1928	*Pastinaca*	GNW	1
	Kenscoff	May 10, 1927	Cabbage	E. Ducasse	1
174-28	Kenscoff	March 14, 1928		E. Ducasse	2
	Mirebalais	Aug. 9, 1928		R. C. Smith	2
118-33	Morne La Selle	Sept. 1933		A. Audant	1
74-34	Morne La Selle	June, 1934		A. Audant	1

MALES

Haiti Acc. No.	Locality	Date	Host	Collector	Number of Specimens
	Mt. Puilsboreau	Nov. 9, 1927	Guava	GNW	1
	Le Trou	Nov. 10, 1927	Guava	GNW	1
59-27	Kenscoff	April, 1927	*Pastinaca*	GNW	1
	Kenscoff	Nov. 23, 1927	*Pastinaca*	GNW	17
5-28	Port-au-Prince	Jan. 12, 1928		GNW	1
171-28	Kenscoff	March 14, 1928	*Clerodendron*	E. Ducasse	4
	Kenscoff	April 4 & 26, 1927	Beans	E. Ducasse	11
59-28	Port-au-Prince	May, 1928		A. Audant	2
	Mirebalais	August 9, 1928		R. C. Smith	1
	Hinche	August 30, 1930		H. L. Dozier	1
	Kenscoff	August 24, 1930		H. L. Dozier	4
104-33	Morne La Selle	Sept., 1933		A. Audant	2
74-34	Morne La Selle	June, 1934		A. Audant	1

A study of the specimens remaining in the collection at Damien, together with fresh material collected at Kenscoff in December 1937, indicates that all represent but a single species, for which the name *hispaniolae* is proposed. This species may be characterized as follows:

Tiphia hispaniolae sp. nov.

Female.—Entirely black, polished, length 15 mm.; head, basal segment of antenna, anterior dorsal pronotum, scutum, legs and posterior margins of abdominal segments with long silvery hairs. Head, coarsely but unevenly punctate, as is also anterior pronotum, with a line of deep punctures almost coalescing to form a deep transverse groove with posteriorly pointing hairs, posterior and lateral pronotum polished and impunctate. Notauli of scutum ending in deep punctures before base, no antero-medial groove, scutum coarsely but sparingly punctate. Preapical groove on posterior aspect of mesepisternum. Prepodeal areola almost twice as long as broad, anterior lateral margins slightly curved outwards, posteriorly straight and parallel, median carina not reaching apex. Median carina of posterior aspect extending nearly to apex. Wings translucent black, lighter in marginal and radial cells, with transparent lines

paralleling the opaque black veins to outer margin. Second intercubital vein somewhat sinuous, joining the radius in a broadly rounded angle. Cubital mark present in large individuals, only at marginal vein in smaller specimens. Hind basitarus not grooved, major calcarium of hind tibia only slightly wider towards middle than at base. First tergite of abdomen with very deep preapical groove, all tergites anteriorly lightly punctured, postmedially almost impunctate, a transverse row of punctures near apex. Pygidium deeply impuctate only on basal half.

Described from 33 specimens, Haiti & Puerto Rico Acc. No. 133–37, collected between Kenscoff and Furcy, Haiti, elevation about 1,700 meters, December 5, 1937 by George N. Wolcott.

Male.—Black, polished, length 9 mm., punctures and pubescence much finer than in female, in this respect quite unlike *Tiphia argentipes* of Cuba, which Cresson (1) describes as ''more slender and hairy (than the female); the punctures of the mesothorax and abdomen deeper and closer.'' Radial cell greatly exceeding second cubital, basal half and apical margin of forewing hyaline, elsewhere fuscous, basal third only not pubsecent, veins black. No denticle on fifth sternite of abdomen. First tergite with deep preapical groove and carina, also a prominent median transverse carina. Cresson mentions no such median carina, in his description of *argentipes;* Miss Sandhouse states that it does not occur in the Puerto Rican males; it does not appear on a single male collected at Santiago, República Dominicana, by S. del Rosario on March 26, 1936, and now in the collection of the College of Agriculture at Mayagüez, P. R., loaned to me for study by Dr. Stuart T. Danforth; therefore this character appears to be distinctive for the males of this species, separating it from others of the Greater Antilles.

Described from a single specimen (TYPE) out of 5 examples, Haiti & Puerto Rico Acc. No. 136–37, collected at Kenscoff, Haiti, December 13, 1937 by George N. Wolcott, compared with 12 examples, Haiti Acc. No. 59–27, collected at Kenscoff, November 23, 1927 by George N. Wolcott. Type and accompanying females for the U. S. National Museum, others for the British Museum, the bulk of the material in the collection at the Agricultural Experiment Station at Río Piedras, P. R. and at Damien, Haiti.

The May beetles of Haiti vary tremenduously in size (4); and no information is available as to which of these several species of white grub is attacked by *Tiphia hispaniolae.* It is possible, however, that despite the selectivity displayed by continental species of *Tiphia,* different instars of approximately the same size of most or all of the grubs of Haiti are attacked by the females of the single species of *Tiphia* found there. If the Haitian *Tiphia* is in fact so unselective in its attack on white grubs, presumably it would attack other species of white grubs in an environment similar to that of Haiti. This would make it a most valuable addition to the fauna

of Puerto Rico, more especially at the higher altitudes where it thrives, but where *Bufo marinus* does not and is thus of so little value in white grub control.

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THE INTRODUCTION INTO PUERTO RICO OF *LARRA AMERICANA* SAUSSURE, A SPECIFIC PARASITE OF THE "CHANGA", OR PUERTO RICAN MOLE-CRICKET, *SCAPTERISCUS VICINUS* SCUDDER

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For many years young tobacco plants in Puerto Rico have suffered from the attack of an insect called by the growers the "changa". Its scientific name is *Scapteriscus vicinus* Scudder, and, altho it is not a native insect, but, merely due to the fact that it appears to be more abundant and to cause more damage in Puerto Rico, it has ordinarily been known elsewhere as the Puerto Rican mole-cricket. (fig. 1.)

The changa occurs mostly in light sandy soils, thru which it can readily burrow with its powerful shovel-shaped front legs. During dry weather it remains at considerable depths in the soil, but during wet weather it comes up, making mole-like burrows just below the surface, feeding on the tender centers of the stalks of whatever young plants may happen to be there. It does not confine its attack to tobacco; it merely happens that the best tobacco soils are also the light sandy soils best adapted to the changa. When such soils are planted to sugar-cane, the changa attacks the young cane shoot quite as readily, and the presence of the changa makes vegetable growing practically impossible in many localities where otherwise it might be a profitable practise.

The changa can be, and is, artificially controlled. Many years ago tobacco growers learned that by wrapping each young transplanted tobacco plant in a broad, tough leaf of the mamey tree, *Mammea americana* L., it would be protected against attack by the mole-cricket until it had grown sufficiently large and tough to be no longer subject to injury. Cane-growers learned that, instead of placing the cane "seed" piece horizontally in the ground and lightly burying it, if stuck in at an angle, roots would start from the lower end deep in the soil, and the upper eyes would send out shoots above the surface of the soil, out of reach of the attack of the changa. Some vegetables can be protected by the method used for young tobacco plants; others can not be grown in "changa" soils, and their cultivation is no longer attempted there. It should be es-

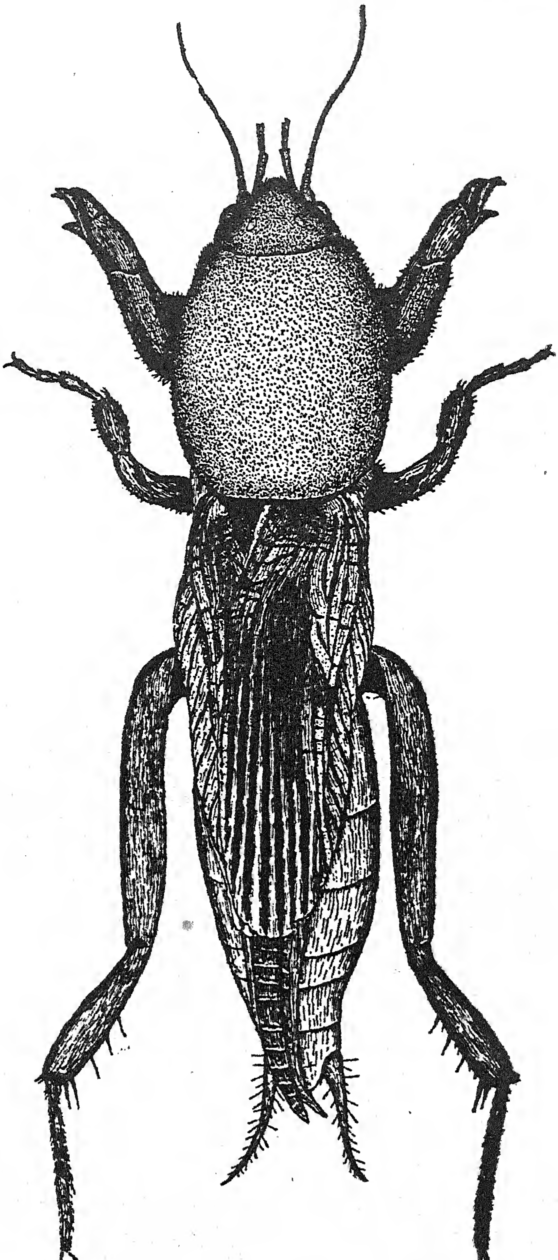

FIG. 1. The "Changa", or Puerto Rican Mole-Cricket, *Scapteriscus vicinus* Scudder, dorsal aspect. Six times natural size. (Drawn by F. Seín.)

pecially noted, however, that these methods of preventing changa injury do not kill the pest, or even tend to reduce its numbers; they merely protect individual plants from attack at that time, and must be repeated for each succeeding crop. Indeed, while reasonably well adapted to small scale cultivation in some tobacco regions, they quickly tend to exhaust all possible supplies of fresh mamey leaves for rapidly expanding, large scale plantation production.

A positive method for destroying the changa (**2** and **6**), consists in the application around each tobacco plant, as set out in the field, of a ring of wheat flour and Paris green, the mixture containing twenty to fifty times as much bait as poison. This poison bait is also applicable for other crops, when distributed as lumps in the prepared field before the crop is planted. The wheat flour proves to be more attractive to the insect than any green vegetation, and is promptly eaten in such quantities that the admixed poison causes death. Because of its effectiveness in ensuring an even stand of tobacco, and despite the very considerable expense involved, this method is in extensive use in Puerto Rico at the present time. No other method suggested even approaches it in value. Manufacturers of aluminum foil suggested that their product might prove more desirable than mamey leaves, but the changa promptly burrows thru any thickness of foil which can be readily wrapped around the roots of a seedling, and also, the foil does not rot and naturally disappear, as do the mamey leaves, when the tougher and older tobacco plant no longer needs protection. Nor do suggested improvements in the Paris green-flour mixture appear to be applicable in Puerto Rico, where the original formula is still universally used. Indeed, the sole objections to its use are on the basis of cost and trouble of application.

Naturally, the control of the changa by natural means has repeatedly been suggested, but the birds which are large enough to be effective (**10**), are scarce or non-existent in the thickly settled regions where tobacco is grown. The large ground lizard, *Ameiva exsul* Cope, which also feeds on the changa (**14**), is almost equally scarce where its presence would be of economic value. Much was expected of the giant Surinam toad, for the changa is more or less comparable in size, terrestrial habits and clumsiness to the May beetle, yet at the time when the toad was most abundant and was most effective in rapidly reducing the numbers of the May beetle, the changa formed but an insignificant fraction (only 2.4 per cent) of its food (**7**), and the proportion has not since been increased (**15**).

The scarcity, or comparative inefficiency in the control of the changa, of all of these larger predators does not by any means eliminate all possibilities of natural contrôl. The search abroad for a specific insect parasitic only on Puerto Rican white grubs was fundamentally hopeless because the local species are endemic and present nowhere else. But the Puerto Rican mole-cricket is unquestionably an introducted insect, as many of the older tobacco growers could remember a time when it was not present to trouble them. Tradition indicates its appearance after the distribution of a shipment of Peruvian guano followed by the destruction by hurricane of most of the large birds which might have consumed these first few introduced individuals. It is not mentioned by Ledru (**8**), and Busck (**3**) notes that Dr. Augustin Stahl, the first Puerto Rican naturalist, told him that "it was a comparatively new insect in Porto Rico, having been introduced within his recollection." Its subsequent abundance in Puerto Rico unquestionably indicates that it has here escaped from its effective natural enemies, and that a search for them abroad might furnish the key to its control in Puerto Rico.

The establishment of the Board of Commissioners of Agriculture in 1911 made possible the first attempt at such a search. Mr. Patrico Cardín, recently graduated from Massachussets Agricultural College and promptly appointed Entomologist at the Experiment Station at Santiago de las Vegas, Cuba, had indeed reported such a specific parasite (**4**), and the writer, at that time employed by the Board in the collection and shipment of parasites of white grubs, was sent to Cuba to investigate. The sole basis for Cardín's statement was a single cocoon which he had picked up in a field being plowed, from which the *Tiphia* wasp had emerged, but in the silken network of threads on the outside of which was still entangled what he supposed to be the skeletal remains of a changa. A more critical examination indicated that what he supposed to be the burrowing forelegs of a changa were in fact the jaws of a white grub.

To more securely establish the actual occurrence of the mole-cricket in Cuba, previously recorded by Cook (**5**) as being present at Santiago de las Vegas, but of which no specimens remained in the collection, Cardín organized an expedition from the tobacco center of San Juan y Martínez on one of the holidays when he was free to be absent from his office in the Experiment Station. The imposing cavalcade, starting long before daybreak, sent out several messengers explaining the object of our search, but it was not until nearly noon, as we were feasting on roast pork and other native

dishes in the shade of a clump of royal palms grouped around a spring, that we were interrupted by an excited and shouting rider bearing a single but unquestionable mole-cricket. Somewhat crestfallen at the reward of a $5 bill, he was only partially satisfied when assured that this was the equivalent of the solid silver dollars which he had anticipated. What became of this dearly obtained specimen is uncertain, for it has not recently been found in the collections in Cuba, Puerto Rico or at Washington. The difficulty of obtaining it, however, coupled with the youthfulness and inexperience of the writer, precluded the further prosecution of a search for its possible parasite at that time.

The erroneousness of Cardín's original observation should not obscure the fact that true parasites of mole-crickets do occur in various parts of the world. Possibly the best known is *Larra luzonensis* Rohwer, which was discovered in 1917 in the Philippine Islands by Mr. F. X. Williams of the Hawaiian Sugar Producers' Association Experiment Station when he was searching for a parasite of *Gryllotalpa africana* P. B. (**11**). This mole-cricket, accidentally introduced into Hawaii, was a serious pest of sugar-cane there until Mr. C. E. Pemberton brought cocoons of the wasp from the Philippines to Hawaii, and reared and successfully established the parasite there (**12**). Each parasite of each species of mole-cricket is specific for that kind of mole-cricket only, thus at once indicating the uselessness of attempting the introduction into Puerto Rico for the control of the changa of the wasp which has been so effective in the control of the mole-cricket in Hawaii. Not only are they different species, the two mole-crickets are in different genera, and hopelessly unlike from the standpoint of their parasites.

The logical place to commence the search for a desired parasite is in a country with a similar climate, where the identical host is known to be present, but, presumably due to its parasite, not abundant. In every way, Cuba appeared to be the most desirable place for commencing a search for a parasite of *Scapteriscus vicinus* Scudder, the "changa" of Puerto Rico. As tentative plans were being made however, the Entomologist at present at the Experiment Station at Santiago de las Vegas, Mr. S. C. Bruner, sent word that a recent determination of all the mole-cricket specimens in the Station collection by Mr. J. A. G. Rehn, of the Philadelphia Academy of Natural Sciences, the recognized specialist in this group, showed them to be *Gryllotalpa hexadactyla* Perty (fig. 2), and that the Puerto Rican changa apparently did not occur in Cuba (**9**). There is no record of a

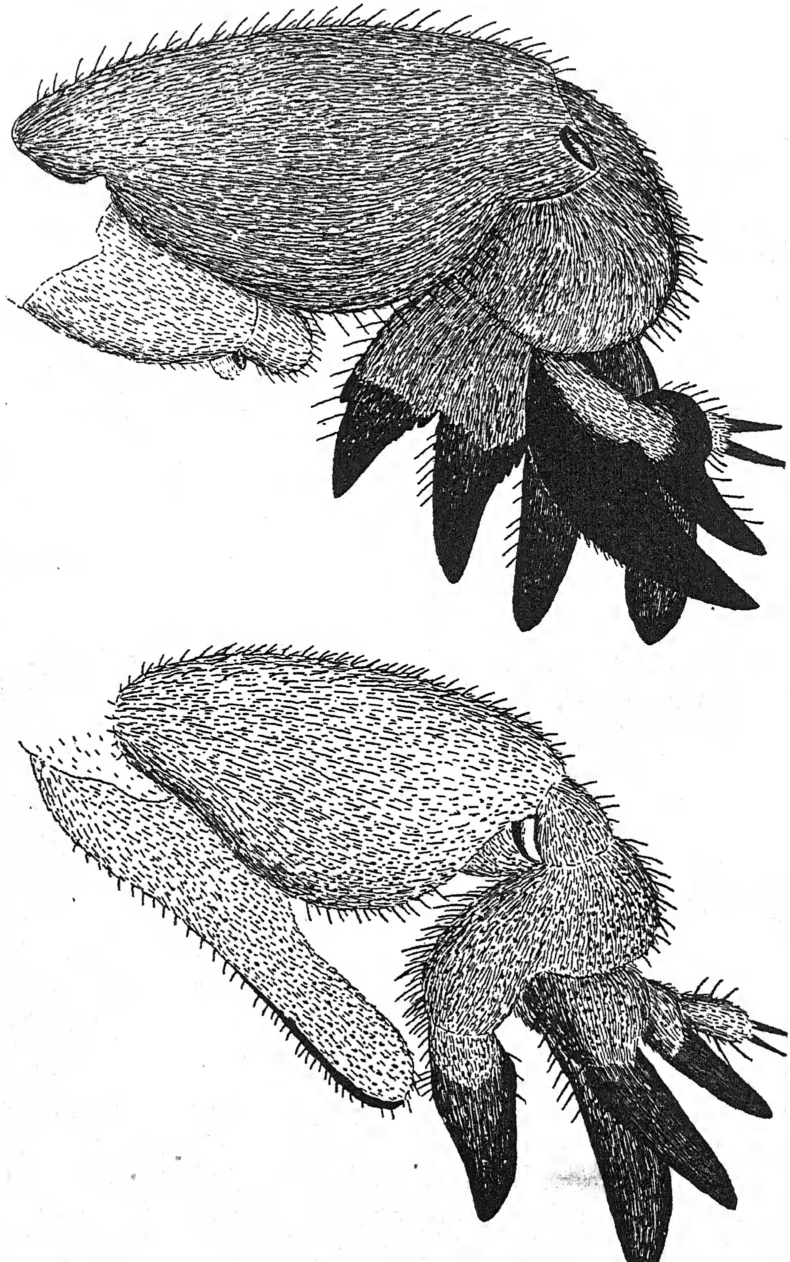

FIG. 2.—Foreleg of the West Indian Mole-Cricket, *Gryllotalpa hexadactyla* Perty (above), for comparison with that of the Puerto Rican "Changa", *Scapteriscus vicinus* Scudder (below). (Drawn by F. Sein.)

mole-cricket in Jamaica, and those from Hispaniola were open to doubt. Concerning the Lesser Antilles little definite information was available, but in Trinidad the writer had collected a number of specimens in 1912, which were still present in the collection at Río Piedras, and were unquestionably the same as the Puerto Rican species. At the time of their collection, various persons in Trinidad were questioned as to the status of the insect, but they knew it only from its injury to cricket fields, and not as a pest to agriculture.

Due to the close proximity of Trinidad to the continent of South America, it was to be supposed that any continental parasite of the mole-cricket would also be present there, and indeed, the presence of a parasite might be inferred from the supposed scarcity of the host. Furthermore, Trinidad is now so close to Puerto Rico by airplane that the problem of transporting the inferred parasite would be correspondingly simple.

The month of January 1936 was spent by the writer in Trinidad, where, thru the courtesy of Sir Geoffrey Evans, Principal of the Imperial College of Tropical Agriculture at St. Augustine, headquarters for the investigation were maintained at the College. No wasp which might be presumed to be a parasite of *Scapteriscus vicinus* was collected at this time in any part of the Island, all parts of which were explored, nor was any changa with indication of parasitism noted either at light or in fields being plowed. Indeed, the whole theory of the scarcity of the changa in Trinidad was found to be a misconception. Much of the Island is in virgin forest, or artificial forest of cacao, coffee and grapefruit trees. Furthermore, most of the area under cultivation to sugar-cane is heavy clay soil, entirely unsuited to the mole-cricket. But in the sandy open areas, such as the Savannah at Port-of-Spain, the campus and farm of the Imperial College, and Orange Grove Estate (in sugar-cane), the changa is in general more abundant than in Puerto Rico. And, judging by conditions observed about the lights on the campus, the Surinam toad is even less effective than in Puerto Rico in reducing its numbers.

By a most fortunate combination of circumstances, however, the time spent in Trinidad was productive in indicating where the parasite was to be found and how it might be collected. Mr. A. M. Adamson, formerly of Hawaii and at present Reader in Entomology at the College, possessed a copy of a paper by Mr. F. X. Williams (**13**) detailing his earliest searches for a parasite of the Hawaiian mole-cricket, in which an extended account, with beautiful illustra-

tions, was given of his finding *Larra americana* Saussure, a parasite of *Scapteriscus didactylus* (Latreille) = *vicinus* Scudder, in abundance at Belem, Pará, Brazil. Mr. Alan Pickles, Entomologist for the Department of Agriculture of Trinidad and Tobago, stationed at the College, had spent some weeks at Belem only a year or two before, and was of invaluable assistance in furnishing information about this part of Brazil, and more particularly, a letter of introduction to Dr. G. Hagemann, Zoölogist of the Museu Paraense Emilio Goeldi at Belem.

The official restrictions on the activities of foreign scientists (presumably directed primarily against pseudo-scientists and slippery crooks engaged in expeditions "Exploring for Profit") in Brazil at the present time are most strict, but due to Dr. Hagemann's efforts, an official permit to conduct investigations and to ship the parasites was promptly obtained. It should not be imagined, because of the reluctant and jittery attitude of official Brazil towards foreign scientists, that this in any way reflects the actual sentiments of individuals, or at least of those met by the writer during his stays in Belem. From the manager of the local airport of Pan American Airways, Mr. Alberto Soares, and his assistant, Mr. Mario Pereira da Rocha, and the manager of Hotel Grande, Mr. Julio Lima Lages, all three of whom were of invaluable assistance, to the casual passer-by intent on disposing of a snake around his neck, or a turtle on his head, or birds in cages, or numerous school-children volunteering to aid in catching "borbolêtas", everyone was uniformly most cordial and helpful.

Belem is now only a day's hop by airplane from Trinidad. Early on the first morning after arrival, on the outskirts of the city, along the railroad right-of-way reached by the carline marked "Souza", females of *Larra americana* were seen exploring changa tunnels in search of their host. A little later in the day, they began to frequent the flowers of *Borreria verticillata* Meyer (as determined by Mr. José I. Otero, of the Agricultural Experiment Station at Río Piedras), a plant which is common everywhere in Puerto Rico where the changa occurs. It is also so very abundant in Trinidad that the most extensive collections of the larger Hymenoptera were made from its flowers, but included no specimen of *Larra*. *Borreria* occurs mostly in fields being fallowed, in waste areas, in dry, unpastured meadows, and especially along railroad tracks, where, being least disturbed, it often grows in clumps as high as one's waist or shoulder.

In Belem indeed, it is only along the right-of-way of the railroad to Braganza that so many such large clusters are to be found that considerable numbers of Larrid wasps can be collected in a short time.

Mr. Williams had so meticulously recorded his observations in Belem that the wasps could be at once recognized: entirely black except for golden pubescence and bright chestnut red abdomen (fig 3). The field identification by the writer has since been confirmed by Miss Grace A. Sandhouse, from a large number of specimens sent to the U. S. National Museum, of which 85 were *Larra americana* (Sauss.), 1 *Larra altamazonica* Williams and 1 *Larra pacifica* Williams. He did not especially remark on how very quick and active they are when not on the ground, or how extremely wary and difficult to catch in the net when feeding at *Borreria* flowers, this being reserved for the writer to discover. He did note, however, that they died within a day or two in captivity, thus the problem of getting them alive to Puerto Rico appeared correspondingly difficult. A trial sending to Trinidad, however, showed that a few at least might survive the trip, and two weeks later the writer was en route back to Puerto Rico, accompanied by a Wardian cage of local manufacture, in the moist sand at the bottom of which had been thrust the cut ends of *Borreria* flower stalks, to provide nectar for the 78 wasps of *Larra americana* which it contained. Leaving Belem early in the morning at the time, one could at the earliest expect to be in San Juan by late the next afternoon. Mr. Francisco Seín, Assistant Entomologist, had managed, with the greatest difficulty, to collect 21 live changas to expose to the tender mercies of the expected parasites—actually only a fraction of a day's supply for the 25 wasps which survived the trip. It seemed much wiser to release the wasps immediately near Punta Las Marías, and hope that they could find a more abundant supply of food for their progeny than could be obtained by our activities. Released towards the beginning of a drought that lasted for three months longer, this was doubtless a vain hope, but at that time the vital importance in the wasp's economy of daily rains could hardly have been surmised. Even if this particular release did not result in the establishment of the parasite of the changa, the trip had at least shown where the parasite might be obtained in numbers, and, with the rapid transportation now possible by airplane, that some wasps would survive the trip for release in Puerto Rico. Apparently nothing more was lacking for a successful introduction than the opportunity to apply on a larger scale the information already obtained. Actually, to get so many wasps alive

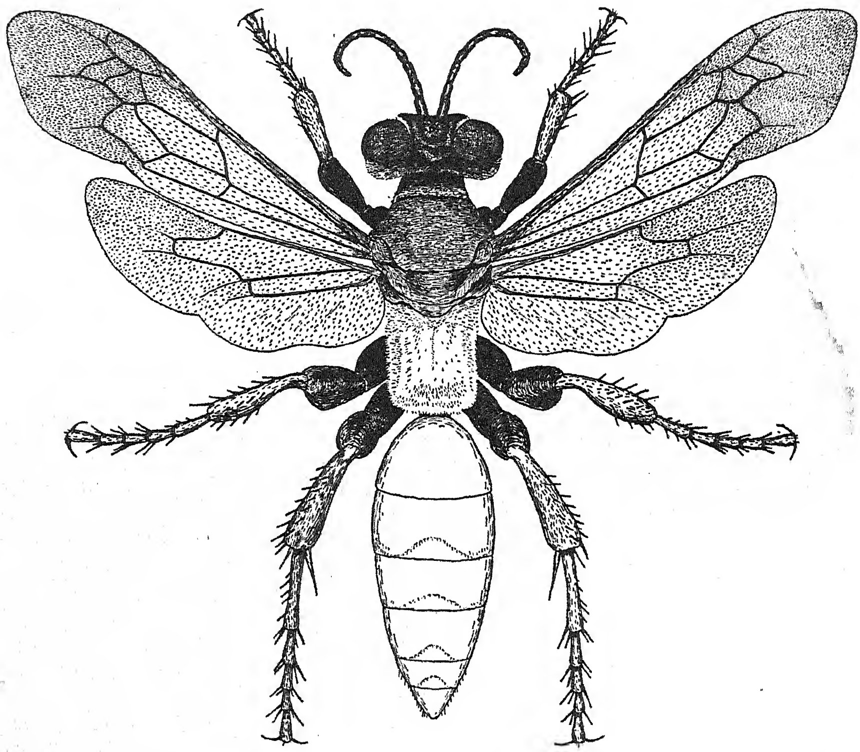

FIG. 3. Adult female wasp of *Larra americana* Saussure, five times natural size. (Drawn by F. Seín.)

to Puerto Rico at one time, and at the first attempt, was a most astounding bit of luck, altho in reality a misfortune because it gave no indication of the difficulties to be experienced later in attempting its duplication.

Belem is by no means as far south of the Equator as San Juan is north, but for these two localities the time of occurrence of the wet and dry seasons is reversed. The daily rain in the wet season at Belem, or at least at the beginning and towards the end of the wet season there, was admirably described in 1848 by Mr. H. W. Bates in his "The Naturalist on the River Amazons".

"On most days in June and July a heavy shower would fall at some time in the afternoon, producing a most welcome coolness. The approach of the rain-clouds was after a uniform fashion very interesting to observe. First, the cool sea-breeze, which commenced to blow about ten o'clock, and which had increased in force with the increasing power of the sun, would flag and finally die away. The heat and electric tension of the atmosphere would then become almost insupportable. Languor and uneasiness would seize on every one; even the denizens of the forest betraying it by their motions. White clouds would appear in the east and gather into cumuli, with an increasing blackness along their lower portions. The whole eastern horizon would become almost suddenly black, and this would spread upwards, the sun at length becoming obscured. Then the rush of a mighty wind is heard through the forest, swaying the tree-tops: a vivid flash of lightning bursts forth, then a crash of thunder, and down streams the deluging rain. Such storms soon cease, leaving bluish-black motionless clouds in the sky until night. . . . The following morning the sun again rises in a clouless sky, and so the cycle is completed."

The female *Larra* normally has just such a definite cycle of daily activities. The early morning hours are spent on or in the ground in a search for changas, forced to the surface of the soil by the soaking rainfall of the previous afternoon. When the ground and the vegetation has been somewhat dried by the morning sun, and especially if she has succeeded in depositing one, or two, or even three eggs on as many changas and the stimulus for further search for a host for her progeny has disappeared, she then begins to frequent the flowers from which she obtains nectar. The wasps feed only during the hottest hours of the most intense mid-day sunshine, and even when the usual rain does not occur in the afternoon, rarely are to be noted feeding very long after mid-day. The passage of a cloud over the sun almost instantly stops their feeding activities, which are not resumed again from rest in the depths of a thicket of *Borreria* and other weeds until it is again shining brightly. What the wasps do during rain and at night can not be asserted with certainty: those in captivity mostly rested quietly on vegetation or

on the sides of the container, altho it is possible that some of them may have been burrowing in the sand, or resting quietly in it during part of this time of inactivity.

Mr. Bates' description of the daily shower and the above notes on the activity of *Larra* apply only to normal weather. The wasps are profoundly affected by any deviation, their cycle of daily activities being predicated exactly to a definite time for the rain. At the time the writer first landed in Belem early in February, the downpour came between 1 and 2 P. M. By the end of the week, the time of this daily storm had advanced to noon, and the practical impossibility of continuing the collection of the wasps by the end of that week was caused by the rain beginning in the middle of the morning. The female *Larra* feed at flowers, where they can be collected, from 10 A. M. to noon, and if the rain commences soon after 10, they never reappear at flowers in any considerable numbers that day, even tho later the sun comes out and the vegetation dries off before nightfall. Males may occur on flowers in the afternoon after a shower, and also earlier in the morning, their feeding of course not being disturbed by the necessity for oviposition, which is doubtless the most powerful stimulus determining the activities of the females. It had seemed wise, therefore, to take back to Puerto Rico what wasps had been collected during the second week in February, and to return to Belem for more later in the spring, towards the end of the wet season there, and incidentally towards the beginning of the wet season in Puerto Rico.

As it happened, the time of return was properly timed for May, and the wasps were present then in an abundance comparable to, or even greater than that observed in February. They no longer frequented the flowers of *Borreria* however, but in the same places where collections were made in February, extensive growths of *Hyptis atrorubens* Poit. (as determined by Mr. Otero), a recumbent plant and not noted before, were now knee-high, and their flowers were greatly preferred by the wasps. Little difficulty had been experienced in keeping the wasps alive for several days in February, but in May few of them lived overnight in captivity, and the bulk of them were dead by the second day. This only duplicated the experience recorded by Mr. Williams, who also was in Belem in May and June. Difficulties also were experienced in making the shipments on time, for the planes from the south three times during the month were two days late in their schedule, due to bad weather in crossing the Andes from Santiago. Out of shipments of 70 or 80 wasps eventually

despatched from Belem, only one or two wasps would arrive alive in San Juan. The carefully designed container which seemed to embody every factor essential to the comfort and well-being of the wasps en route was promptly discarded in favor of a much larger one, and with little better results until the final shipment. In the meantime, as the end of the wet season approached, the daily rains came later and later in the day, and sometimes not until after dark— or not at all. On the possibility that the wasps in captivity might to suffering from lack of humidity, their container received an artificial rain under the shower-bath as soon as brought from the field, but with little apparent effect on the mortality.

Incidentally accompanying the rainfall in Belem is a sudden sharp decline in temperature. On the bare possibility that comparable artificial cold might have the effect of keeping the wasps alive, they were placed in an electric refrigerator, and when removed a few hours later all were dead. The manager of the Grande Hotel suggested that he had two refrigerators: the new electrical one for freezing, and the old one using real ice in which the temperature, while considerably cooler than the air outside, never came within 10° or 20° of freezing. Another collection of wasps placed in this old "real ice" cooler early in the afternoon and removed at dark had suffered not a single mortality. All the final collections of wasps were accordingly placed in this old-fashioned refrigerator during the hot afternoons.

But now that a practical method had been found for keeping the wasps alive longer, difficulty was experienced in collecting them. The daily rains ceased to be daily, and for each day that there was no rain, the number of wasps which could be collected in the field was a fifth less than on the previous day. At first this was not serious, but when no rains at all came during the second week in June, it became abundantly obvious that no large numbers of wasps would again be collected for the next six months, or until the beginning of the next rainy season. Out of the final shipment of only 18 wasps however, 7 arrived alive in San Juan: the highest survival from any shipment, and comparable to the first in February in the Wardian cage. The wasps in this final shipment had been refrigerated in the afternoons, and their container placed outdoors at night, including the night preceeding the date of shipment. As there is no stop for the planes north of Belem closer than French Guiana, they usually cover this longest hop at a great height, with the temperatures approximating those of a mountain, and in general, the

planes are comfortably cool while in motion. The only high temperature experienced for any considerable length of time en route, therefore, is in the late afternoon and early evening at Port-of-Spain, and, with present flying schedules, this is hardly capable of alteration.

For the collection of *Larra* wasps in the field, the writer has used a small, non-folding, metal frame net presented by Mr. F. W. Urich, for many years Entomologist of the Department of Agriculture of Trinidad and Tobago. For handling live wasps, one has much greater confidence if wearing a heavy cotton glove on one hand, altho after some experience, one makes sure of the sex of any doubtful individual by letting it attempt to sting, and releasing any unable to prove that they are females. The container at first used in the field was loaned by Mr. K. A. Bartlett, of the Foreign Insect Introduction Division of the U. S. Bureau of Entomology & Plant Quarantine, but it proved quite unsuitable for the shipment of large wasps. That later designed was manufactured in Brazil by a cabinet-maker recommended by Dr. Hagemann, and measured 3″ × 3″ × 6″, with a circular opening slightly larger than one's thumb, stoppered with a cork, in one end, thru which the wasps were transferred from the net. To induce them to enter voluntarily, the slide top had cut in it a hinged door, closely screened inside. By opening this door just before the wasp was released from the net, its violent positive phototropism promptly carried it into the container. The bottom third of the container was partitioned off with coarse wire mesh of such size that the wasps could readily pass, if they desired. This third of the container was mostly filled with moist sand, but prevented from coming out by a layer of wet sphagnum moss next to the wire. The cut ends of *Borreria* or *Hyptis* flowering stalks were thrust thru this wire mesh into the moist sphagnum and sand, and invariably arrived fresh and unwilted at the end of journey in San Juan, according to the testimony of Mr. Seín. Regardless of their theoretical value, few wasps survived the trip to Puerto Rico in these small containers, and eventually their use was restricted to collection in the field, for which they were well adapted when the wire partition, sand and moss were removed, the interior being loosely filled with wet excellsior and a few flower blossoms. The larger and much simpler shipping cage used for later consignments had only a 5″ × 8″ wire screen window in its sliding top. The transferrence of the wasps from the collecting cage to the shipping cage, or to the Wardian cage, was always attended with difficulty, and whatever method was used, before the operation was completed, one invariably wished he

had used some other. At first it was conducted in bed with the mosquito bar tucked in securely on all sides, and later, at night in the bath room from which everything movable had been removed. By sliding back the tops of the two containers so that their openings were opposite, the moist excellsior in which most of the wasps had come to rest could be droped into the shipping cage, but some invariably chose to remain in the field cage, and others became active and escaped where the openings of the two cages did not exactly meet. In such an extremity, a gloved hand might recover those which hid in the folds of the mosquito bar, or which did not at once escape, despite the darkness outside, thru cracks around the door. The bottom of the large shipping cage was covered with a thin layer of moist sand, into which the cut ends of the flower stalks were thrust, and naturally such cages had to be kept right side up, but the superior survival of the wasps in the larger containers much more than justified the trouble of getting the wasps into them, and the greater care that had to be taken of them en route. To prepare for delivery to the plane, several thicknesses of toweling were tied over the screened window, and saturated with water so as to arrive still damp two days later

Mr. Williams has recorded the finding of *Larra americana* in lesser abundance at more southern localities in Brazil, and of other species of mole-cricket parasites in Equator. Such records are valueless in considering localities from which shipments might more readily be made to Puerto Rico, but at least indicate a wide distribution of such parasites. To determine if *Larra americana* might not occur at localities even nearer to Puerto Rico than Belem, the writer stopped at Paramaribo, Dutch Guiana, on his return in June 1936. Plants of *Borreria* were not noted, but quite extensive beds of *Hyptis* were found at the end of a country road "Charlesburgstraat" in a clearing at the edge of the forest, and feeding on the nectar of their flowers were females of *Larra americana*. If the insect ocurs north of the Amazon River, it presumably is present in all suitable sandy regions of tropical South America. The last stop of Pan American Airways on the continent before reaching Trinidad is Georgetown, British Guiana, but the soil here, unlike that around Paramaribo, which is sandy swamp, is mud. Even where it becomes somewhat coarser in texture, neither of the plants frequented by *Larra* for nectar was noted, altho mole-crickets are present in small numbers in the sandy foreshore outside the seawall, and to a lesser extent in the golf course at Belair, in the outskirts of Georgetown. A day's

journey into the interior and they become abundant, for Mr. T. A. W. Davis, Forester at the Mazaruni Station, reports them a serious pest in his nurseries, the specimens submitted by him being both *Scapteriscus vicinus* and *Gryllotalpa hexadactyla.* Thus, British Guiana is indicated as being no nearer Puerto Rico, from the standpoint of transporting the wasps, even if they do occur there, than is Belem. Dutch Guiana remains a definite possibility, altho lack of local transportation, and the limited area where *Hyptis* was noted there, makes Belem still the more desirable locality for the continuance of the attempt at the introduction of a parasite of the changa into Puerto Rico, and the beginning of the rainy season the most favorable time.

Normally, the beginning of the rainy season in Belem is sometime in December, usually between Christmas and New Year's Day. In 1936, the first rain, after an unusually long, hot and uninterrupted dry season came on December 28th, the day that the writer left San Juan by plane, so that some wasps were available for collection when he first arrived in Belem. But the rainfall in the first three weeks of January consisted of showers so light as to barely moisten the surface of the ground, so that by the middle of the month only a few *Larra* were to be seen, and most of these were males. The first general and heavy rain was on January 17th, 1937, continuing all that day and night and most of the morning of the 18th, the air being alive with winged termites much of this time, and on the second night tremenduous numbers of adults of the common large black cricket, *Grillus assimilis* F., invaded the better lighted sections of Belem. The morning of the 19th was bright and clear and the females of *Larra* suddenly so abundant that one could not keep track of the number collected. Yet out of the 30 or more collected just the day before shipment and sent in the large container by the fast Clipper, making stops only at Paramaribo and Port-of-Spain, and arriving in San Juan before 10 A. M. on the morning of the 21st, only 6 or 7 were alive when received, and only 2 survived to be released at Malesa Sub-Station at Isabela, where the ground was being irrigated every day to bring changas to the surface and *Borreria* was specially grown to ensure optimum conditions for the wasps. The heavy mortality could not be due to a hot afternoon, for the rain came at 2 P. M. on the 19th, and lasted all night. The container was kept during the night on a window-ledge on the third floor of the Hotel Grande, and not delivered for transportation until the morning of the departure of the plane, at which time, so far as could be determined, it was in good condition. What happens to

shipments en route is a matter of conjecture, but the spraying of the planes with pyrethrum insecticide just before arrival in San Juan certainly is most unfortunate from the standpoint of keeping the *Larra* wasps alive. For later shipments, the purser or steward of the plane was personally interviewed in Belem just before the shipment was delivered, and instructions given, in addition to those written on the tag, to pour ice-water on the toweling covering the screen window of the container before landing in Port-of-Spain, to keep the shipment out of the sun after arrival and in the shed at the end of the pier until the following morning, and to keep it in the tail of the plane when the plane is being sprayed at San Juan. So far as can be determined, all the special care had little effect in increasing the survival of the wasps, that of some shipments being most discouragingly low. On the other hand, one shipment of 36 wasps sent by the slow plane from which release could not be made until the following day at Malesa, had 7 wasps alive and active at that time, and the final shipment of 16 wasps, in a container of twice the size of those previously used, with three windows, by the fast plane, had 5 wasps alive for release at Maleza. But the total of 28 wasps received alive out of almost ten times that number collected is a most disheartening record (see Table), relieved only by the assurance that all of these were females and that they were released where changas were not only abundant, but where the daily irrigation surely made them readily available for attack and oviposition, and where *Borreria* was present in abundance.

The mortality of *Larra* was so heavy on the slow planes, with the one most extraordinary exception above noted, that discontinuance of using them was contemplated as soon as the reports began to be received. The slow planes arrive in Trinidad, however, almost as soon as the fast planes do, and as Mr. Pickles was keenly interested in attempting the introduction of *Larra* in Trinidad, and indeed had attempted to rear the parasite there from the first trial shipment made to him in February, 1936, he was asked to receive shipments of the wasps, either for release or rearing. Just at this time, however, he was in the hospital recovering from an operation, consequently Mr. Adamson received the shipment. Out of 27 females sent from Belem, 7 were alive upon receipt, of which 5 were still alive the following morning, when they were placed in individual tubes or petri dishes and supplied with mole-crickets. Before the last one of these had died, Mr. Adamson had secured 21 eggs, and, at last report, several of the eggs had successfully hatched after 9 days incubation.

SHIPMENTS OF *LARRA AMERICANA*, BELEM TO SAN JUAN, 1937

Sending No.	Type Cage	Weather	Wasps Col.	Date Left	Type Plane	Date Arr.	Wasps Alive	Wasps Dead	Wasps Total
1........	Small.	Too dry	21	Jan. 3...	Slow....	Jan. 4...	None....	21	21
2........	Small.	Too dry	14	Jan. 6...	Fast....	Jan. 7...	3	15	18
3........	Small.	Too dry	17	Jan. 13..	Fast....	Jan. 14..	1	20	21
4........	Small.	Too dry	5♂7♀	Jan. 17..	Slow....	Jan. 18..	None....	Not Counted	
5........	Large.	O.K....	Many♀	Jan. 20..	Fast....	Jan. 21..	2	Not Counted	
6........	Large.	O.K....	20♂32♀	Jan. 25..	Slow....	Jan. 26..	2	50	52
7........	Large.	Cloudy.	8♂12♀	Jan. 27..	Fast....	Jan. 28..	4	21	25
8........	Large.	O.K....	36♀	Jan. 31..	Slow....	Feb. 1...	7	29	36
9........	Large.	O.K....	29♀	Feb. 3...	Fast....	Feb. 4...	2	27	29
10........	Large.	O.K....	27♀	Feb. 7..	Slow....	Feb. 8...	None....	27	27
11........	Large.	Cloudy.	17♀	Feb. 10..	Fast....	Feb. 11..	2	15	17
12........	Extra large	Cloudy	17♀	Feb. 17..	Fast.....	Feb. 18..	5	11	16
A to Trinidad	Large.	O.K....	27♀	Feb. 15..	Slow....	Feb. 15..	7, 5 on Feb. 16th, all used in breeding in laboratory	20	27

Except for the one collection of January 19th, 1937, on no other day during January and February of this year were so many wasps collected as on many days during May 1936. Possibly this may have been due to the effect of intensity of the dry season of 1936, or it may merely be due to the fact that no males were collected after the rains had started in 1937, and the wasps were in reality quite as abundant as previously. While the total number collected during a day often was almost as high as in May, the effort and time spent in the field was much greater, and when the daily rains did not come until 2 or 3, or sometimes 4 P. M., the wasps rarely appeared in any numbers during the morning, the bulk of the collection of females being made from noon up to within a few minutes before the breaking of the storm. Few mornings were of uninterrupted sunshine, scattered clouds beginning to appear often just at about the time when the wasps were to be expected, and increasing in number and density as the day advanced so that the wasps found but few intervals in which to fly about and feed in full sunshine. Apparently they can not see as well when the day is cloudy, and certainly they are not as active, wary and hard to catch, even tho fewer of them are available to be caught.

All collections were brought to a sudden termination in Belem by the middle of February by the sudden concerted activity of the municipal authorities in cleaning up the city after carnaval, which consisted in cutting the weeds, not only on the streets in the city, but far out beyond the city line along the railroad tracks where the bulk of the collections were being made. The mowing down of these

dense thickets of *Borreria* did not serve to concentrate the wasps on the few clumps left, for beyond the built-up part of the city, the forest surrounds it on all sides not bounded by the rivers. There are no waste lands or abandoned areas; clearings or burned-over areas in the forest are planted to yuca, or grow up so rapidly to high second growth that *Borreria* has no chance to become established, and in reality the only favorable places for it are along the too-wide roads of the outskirts of Belem, or along the railroad track. The weather also at this time was rapidly becoming less favorable to *Larra,* entire days being cloudy and misty, interrupted, not by sunshine, but by showers, so that even while good collecting areas were still available, the number of wasps that could be collected was rapidly diminishing.

In normal years, Dutch Guiana has a short rainy season during December and January, so that growths of *Hyptis* should be at their height in February, and Larrid wasps abundant. During the one week spent there in February 1937, two wasps were seen, for there had been no short rainy season this year. *Hyptis* growth was still recumbent, but by riding on a bicycle to the end of every road around Paramaribo, its areas of abundance could be located and plotted, for use at times when wasp collections might be made there.

The dishearteningly small number of *Larra* surviving the journey from Belem to San Juan in January and February 1937 seemed to indicate the desirability of finding some closer point of collection, the shorter journey from which might enable more of the wasps to survive. To be sure, Paramaribo, Dutch Guiana, is considerably nearer San Juan, but the airport is so far from points where *Larra* is found that no collections would be possible on the day of shipment. Since Georgetown, British Guiana, is unsuitable, the other points in South America which might be considered are the airports of Venezuela. The one nearest to Trinidad is the oil-field at Caripito, the next is Guanta, the port of Barcelona, both with such frequent airplane service that wasps collected at either point would reach San Juan by the next morning. A personal inspection of Guanta and Barcelona in April 1937 immediately indicated their unsuitability, the area in the vicinity of Guanta being a desert, and Barcelona is hours away by automobile. The presence of *Borreria verticillata* along the banks of the river beside Barcelona might indicate the possible presence of *Larra* during rainy weather, but at the time the survey was made there had been no rain for some weeks, and the presence of adults was not to be expected. Caripito is a clearing in the midst of virgin forest of the Orinoco delta region, rainfall is normally

considerably more abundant than at Barcelona, and *Borreria verticillata* grows in abundance on the sandy soil of the landing field of the airport. April, however, is a month of drought for Caripito, and the only hope of collecting *Larra* was to return in the summer, when the greatest abundance of rainfall is to be expected.

Mr. Luis F. Martorell spent part of August 1937 at Caripito, but despite the apparent suitability of conditions, he collected only a few small *Larra americana* (as determined by Miss Grace Sandhouse), the wasps being so scarce that making shipments of live adults to San Juan was out of the question at that time. His collections and the definite determination of the specimens, however, establishes the record of *Larra* for Caripito, and its scarcity at the time he was there by no means proves that it might not be abundant in other years when total rainfall is more abundant than it was in 1936–37. Caripito remains a possibility to be further investigated if others fail.

The doubtful record of the presence of the changa in Haiti was assumed to refer to *Gryllotalpa hexadactyla* Perty, when the Cuban mole-cricket was definitely determined to be that species. In the summer of 1937, Mr. André Audant, Entomologist in Haiti for the Service National de la Production Agricole et de l'Enseignment Rural, sent a specimen of a mole-cricket collected by a student to the U. S. National Museum for determination. Mr. A. B. Gurney, the specialist in Orthoptera there, identified it as *Scapteriscus vicinus* Scudder, and Mr. Audant, knowing of our great interest in this insect, promptly reported the determination to us. To determine whether the scarcity of the Puerto Rican mole-cricket in Haiti was due to control by a parasite, two weeks in November and December 1937 were spent there. In Mr. Audant's automobile, nothing of interest was noted driving northwest from Port-au-Prince to St. Marc and in the valley of the Artibonite, but on the second day going west towards Petit Goave, three live changas were collected in a sandbar in the bed of a stream. This is the first definite locality collection of *Scapteriscus vicinus* in Haiti.

The greater part of Haiti is mountainous in character, the central plain of the Cul-de-Sac being heavy clay, and most of the stream deltas consist of loose rocks and bowlders, succeeded immediately by clay, with no intermediate sandy area where the changa might find conditions suitable for its existence. Thus the sandy stream bed at Petit Goave, where these changas were found, in reality is quite exceptional for Haiti.

An exceptionally complete herbarium of the plants of Haiti is to be found at the Damien office and school of agriculture, having been assembled by Dr. Erik Ekman of Uppsala, Sweden. He collected specimens of the two plants at the flowers of which *Larra americana* is most commonly found in Brazil: *Hyptis atrorubens* between Port Margot and Bayeux on the north coast, and *Borreria verticillata* at Morne Brouet, south of Kenscoff, at an elevation of 1,600 meters. As Ekman was more likely to collect from relatively inaccessible localities, rather than in those more readily reached by automobile, to search for *Borreria* in the region where he found it required several days of travel afoot. The mountains between Port-au-Prince and Kenscoff were tramped over one day, and three days were spent at Kenscoff, and on one of the mountains south of Kenscoff, at an elevation of possibly 1,700 meters, large clumps of an undetermined species of *Borreria* or *Mitracarpus* were found. They were growing mingled with such temperate zone plants as blackberry, mullein, wild carrot, narrow-leaved plantain, dandelion, St. Johnswort, chick-weed and white clover. Hours were spent watching them during the middle of the day in bright sunshine, but no wasp even remotely resembling *Larra* was noted. Considering the low temperature (except in full sunshine), and the soil, which is a heavy clay, the absence of *Larra* is hardly surprising, and further search in the Kenscoff mountain region was discontinued.

The only sandy beaches in Haiti near Port-au-Prince, aside from those previously investigated towards St. Marc, are on the southern coast of the southern peninsula. A one day trip to Jacmel was most disappointing in its results, the only sandy beach being just at the city, and used for a public dump. A two day trip to Cayes showed little more of tangible value, for the beaches between Aquin, St. Louis du Sud and Cayes are comparatively narrow, and back of them the soil is clay, with bare rocks or steep mountains rising close behind. The sand bar across the mouth of the river at Cayes is extensive, but neither *Hyptis* nor *Borreria* grew there. No trace of the changa was noted, altho rain of the day of going would have made its presence visible the next day coming back if it had been at all abundant. Thus the net result of three days travel over rough roads was entirely negative: no changa and no plant on the flowers of which *Larra* might be expected to occur, altho conditions of temperature and rainfall, and soil for limited areas, would appear to be somewhat more favorable than in the region nearer Port-au-Prince.

While the period spent in Haiti was too short to eliminate all possibilities, it would appear that in the area which may be reached by automobile in a day from Port-au-Prince, the changa occurs in very limited regions, and the plants at which *Larra* is found in Brazil do not occur at all. The scarcity of the changa is thus presumably due to the limited environment in which it can occur, and not due to the presence of a specific parasite.

The possibilities of collecting *Larra* at points nearer by airplane to San Juan having been temporarily or entirely eliminated, refinements and improvements in methods and technique from Belem still remained to be tried, and in the middle of January 1938, Mr. Luis F. Martorell proceeded to Brazil. During the few days less than a month that he was there, six shipments of *Larra* were made, and one was brought with him, small in number of *Larra* adults as compared with those of previous years, due to unfavorable and abnormal weather in Belem, but otherwise the most successful of any yet made. The weather during January and February 1938 was also most abnormal in Puerto Rico, being especially favorable for the introduction, and releases could thus be made less than half an hour from the San Juan airport, in an extensive sandy area to the south of the Laguna de San José which is most nearly comparable in Puerto Rico to the region from which *Larra* comes in Brazil. The releases were made beside an acre previously in cultivation which is now almost a solid mat of *Hyptis atrorubens,* while high plants of *Borreria* are numerous in near-by pastures and areas not in cultivation. During the time that the shipments were being received, the weather of this region, while not exactly the same as Belem at this time of year with rains early in the afternoon, was sufficiently similar in essentials, for in Puerto Rico the rains came nearly every night or early morning, with the middle of the day bright and clear. The exceptional weather in Puerto Rico this winter is a very important factor favoring the success of the introduction.

In regions where mole-crickets are abundant in Trinidad and Puerto Rico, many of them will come to light on rainy nights, but none was thus noted by the writer at Belem during the months spent there. Mr. Martorell was determined to obtain at least a few specimens, and going out at night with a flashlight and a boy to dig, succeeded in obtaining several on the first attempt. The boy subsequently obtained many more, for which he was paid at the rate of 3 cents for each specimen. Mr. F. X. Williams has related how he induced *Larra* wasps to attack and parasitize mole-crickets

in captivity, and Mr. Martorell, using similar methods of introducing the wasp into a small tube with the changa, and shaking them up together if the wasp at first showed no interest, succeeded in obtaining many artificially parasitized mole-crickets. In all shipments except the first two, such parasitized changas were sent to San Juan with the wasps, and one shipment consisted only of such *Larra* in the egg stage. Some of the changas died en route, but over three-fourths of them survived the journey and the close confinement, and most of these were released upon arrival. Of those which were retained in the laboratory, eggs which had been laid previous to January 26th hatched within a few days after receipt, and had grown to full sized maggots by two weeks later (February 14th), the air temperature recorded beside them during this period varying from 72° to 78°F. Only one maggot, however, succeeded in forming a cocoon, and even this one died before transforming to adult. The weight of cocoon and contents was .3145 gr., but this is not net, as it includes grains of sand stuck in the viscous dark brown plastic of which it was composed, which could not be separated out.

The live weight of a changa is .78 gr., its air-dry (dead) weight .287 gr., and subtracting from this the heavily chitinized remains not available for consumption by the parasitic maggot which weighed .077 gr., gives .21 gr. as the net air-dry weight of the food eaten by *Larra* in its parasitic stage. The air-dry weight of large *Larra* females is .0524 gr., and of *Larra* males .022 gr., thus it would appear that the food eaten by the *Larra* may be as little as four times for females, or as much as ten times for males, as the weight of the adult which it becomes. It is much more likely that parasites on the largest changas become females, while smaller changas or large nymphs furnish only food sufficient for the development of males, and the efficiency in the consumption of food by the larval *Larra* is substantially that previously determined by the writer for other parasitic insects (**16**).

In keeping the changas in individual cans with sand and corn, no mortality of the host is experienced after those injured in transit have died, but eggs or maggots are easily killed or dislodged in attempting to examine the active changas for their presence. Thus, only the parasitized changas of the first shipment were retained in captivity, mostly to determine the rate of development of the parasite, and all subsequent parasitized mole-crickets were released in the field. Of the total of 121 parasitized changas sent from Belem, 95 arrived in San Juan alive, and of these, 79 were released in the field at the same time as the wasps.

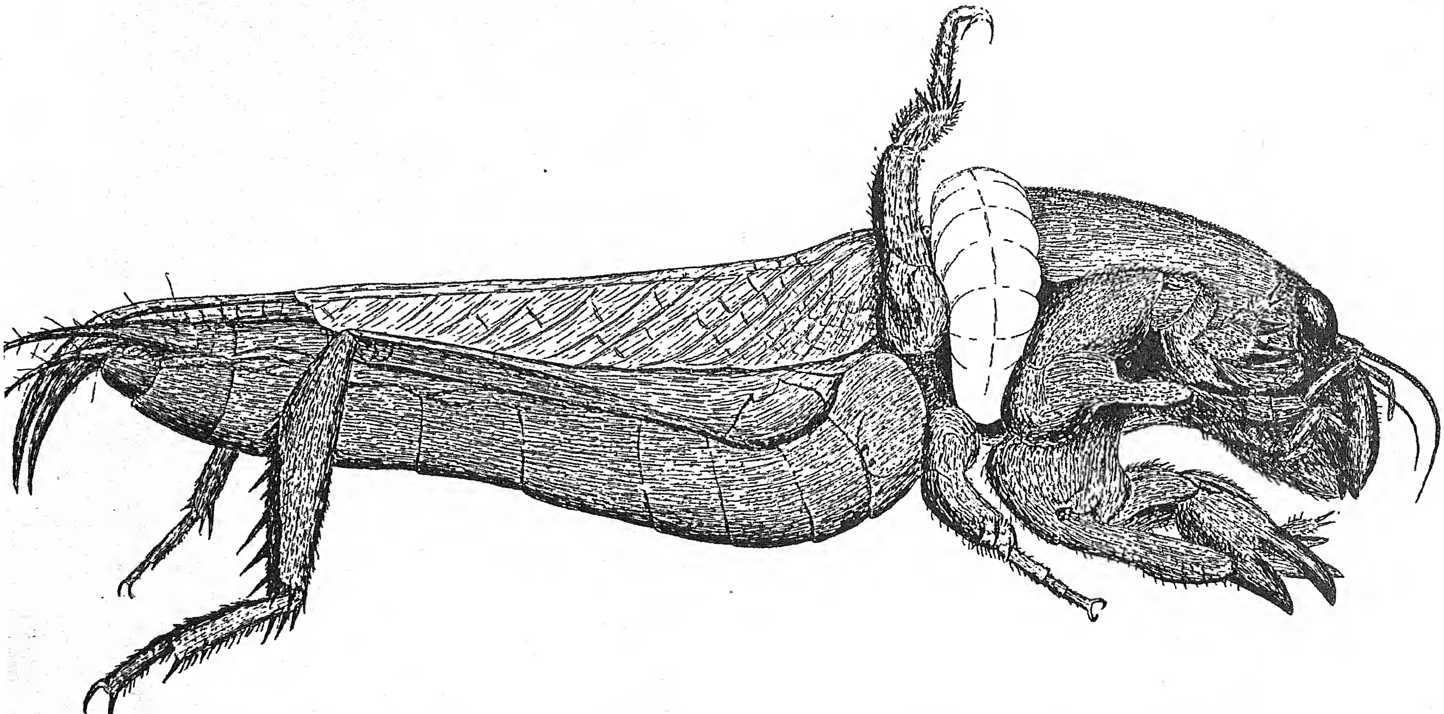

FIG. 4. Maggot of *Larra americana* feeding on the juices of a ''changa'' killed by it. (Drawn by F. Seín.)

Quite aside from the number of *Larra* thus introduced in the egg stage, the presence of the parasitized changas in the box with the wasps had a most surprising effect in greatly reducing their mortality. In the first two shipments made without changas accompanying, only one wasp arrived in San Juan alive; of the succeeding shipments which had a screened box or can of parasitized changas, the first contained 11 live wasps, 1 weak and 6 dead, the second contained 18 live wasps and only 1 dead, the third had 9 live wasps and only 2 crushed under the box of earth and changas, while the final shipment brought by Mr. Martorell in person, but delayed en route an additional day at Trinidad, had 7 live wasps and 4 dead. This is so much better than any previous series of shipments as to indicate that the presence of live changas is quite essential for keeping the wasps alive en route, and will of course be used in all future shipments. It appears to be the key to the problem: the solution of how to get the wasps alive from Belem to San Juan. The total number of wasps sent by Mr. Martorell this year was 81, of which 35 arrived dead and 46 alive, as compared with 262 shiped last year, but of which only 28 arrived alive. The difference in the total number indicates the much less favorable weather in Belem for making the collections, while the much larger proportion of wasps arriving alive shows the more successful method of shipment accompanied by changas. The total of only the shipments accompanied by changas is even more clearly indicative of the success of this method: 59 wasps sent, 45 arrived alive, with only 14 dead.

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NEW SPECIES OF *NEMOCERA* FROM PUERTO RICO

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During the months of February and March 1935, Dr. J. G. Needham of Ithaca, New York, in company with Dr. Julio García-Díaz of Río Piedras, P. R., collected numerous insects on the island of Puerto Rico, a collection which was considerably augmented later in the season by Dr. García Díaz working alone. Of the Diptera obtained several of the nemocerous families were placed in my hands for identification. Owing to the fact that it was necessary to collect the specimens in alcohol several of the Psychodidae could not be identified. This was true also of some species of other families where represented by females or defective specimens alone. A list of the more striking captures as well as descriptions of previously undescribed species are given herewith.

Chironomidae

Pentaneura marmorata n. sp.

♀. Head and antennae pale yellow, apical antennal segment, the elongate palpi and mouthparts infuscated. Twelfth segment of antenna three times as long as the eleventh segment. Thorax and scutellum pale yellow, mesonotum with four broad brown vittae; lateral margins of metanotum and of pronotum brown; pectus largely brown; pleura with about ten irregular brown spots of varying sizes. Abdomen pale yellow, tergites 3, 4 and 5 each with a large rectangular brown spot. Legs yellowish white; extreme bases of coxae, a spot on trochanter, a preapical ring on each femur, a ring near base of each tibia and the extreme tips of the tibiae and of the metatarsi, brown. Fore basitarsus scant 0.6 times as long as the tibia, pulvilli absent. Wing marmorated with brown spots as follows: an irregular rectangular spot covering humeral crossvein and arculus; an irregular triangular spot covering the r-m crossvein, extending to the costa; a large brown rectangular area extending from the tip of R_1 to apex of wing covering the costa and the media, this area with a small hyaline spot along the costa between R_1 and R_2; a large irregularly 4-branched hyaline spot between radius and media, and another less distinctly margined irregular hyaline spot near apex of the wing; in the basal half of cell R_5 and just beyond the r-m crossvein with three small dark brown oval spots of which the more distad is the smallest; m-cu crossvein covered in part by a small spot, distad of which in cell M are about four more or less square spots, the apical one containing a vaguely margined hyaline spot; Cell C_1 with two minute basal spots, a square spot filling the space above apex of Cu_2 and the cell apically brown margined; behind the cubitus there are about three

small spots basally, a large square spot under the base of Cu_2 and distally filling the margin under the apex of Cu_2 an irregular brown area containing an indistinctly margined hyaline spot. The larger wing spots are more or less contiguous with one another. Squamae fringed. Halteres white. Length 2.5 mm, wing 2.4 mm.

Type from Río Cidra, Puerto Rico, March 23, 1925. In the Cornell University Collection.

Pentaneura monilis L., var. *peleensis* Walley.

Taken at light, Tortuguero Lake, August 15, 1935.

Coelotanypus insulanus n. sp.

♀. Head and antennae yellow, apical antennal segment brownish; eyes slightly emarginate, separated at vertex by a width equal to the distance between the bases of the antennae; thorax including scutellum reddish brown; pleura yellow, metanotum dark brown; mesonotum without acrostichals, the pimple on disc, small. Abdomen yellow, tergites 2 to 7 with basal half or two-thirds, brown, eighth tergite and sternite more or less brown. Femora yellowish, apical sixth dark; tibiae yellow, bases of fore and hind pairs and apices of all of them brown; fore tarsi broken off, the apices of the first and second segments of middle and hind tarsi yellow, their apices and the whole of the remaining segments dark brown. Fore tibiae with one, middle and hind tibiae with two spurs. Wings hyaline, veins yellow, r-m crossvein dark brown; petiole of cubitus about half as long as the m-cu crossvein; anterior branch of the cubitus slightly undulate. Squama fringed. Halteres yellow. Length (in alcohol) 2.2 mm.

Yúnez River, Puerto Rico, August 11, 1935. Type in the Cornell University Collection.

Coelotanypus concinnus Coquillett.

Taken at light. Cartagena Lagoon, August 9.

Cardiocladius obscurus Johannsen

Taken at light, Cartagena Lagoon, August 9.

Cricotopus aberrans n. sp.

♀. Head yellow, occiput, antennae and mouth parts slightly darker. Eyes pilose, widely separated on the front. Antennae with six segments of which the last is three times as long as the fifth. Thorax yellow, with the three broad vittae on mesonotum, the scutellum and metanotum, brown. Abdomen yellow, the apical half of the second tergite the whole of the third, and the sixth, seventh, eighth and ninth tergites except narrow bases, brown. The terminalia, which are white, resemble those figured for *Orthocladius absurdus* (N. Y. State Museum, Bull. 86, Plate 33, 7) with about five strong bristles at apex of each

lobe. Femora whitish with apical third dark brown; fore tibiae white, apical third dark brown, the other tibiae yellow, extreme base of second pair and basal third of hind pair more or less brownish; fore tarsi wholly dark brown, middle and hind tarsi infuscated toward the tip; pulvilli lacking; empodium long; fore basitarsus 0.6 times as long as the tibia. Wing hyaline, veins yellowish, costa produced, cubitus forks distad of the crossvein. Squama not fringed. Halteres white. Length 1.8 mm.

Type from Tanamá River, Puerto Rico, March 12, 1935.

Paratypes from the same locality March 12, 13 and May 11; from Yúnez River, Feb. 27, and Cagüitas River, March 3, 1935. Type in the Cornell University collection.

The color of the middle and hind tibiae in the paratypes shows some variation.

The *Orthocladius absurdus* Joh. noted above will fall in *Cricotopus* as defined by Edwards in 1929. *Cricotopus insolitus* Curran also from Puerto Rico has a similarly constructed terminalia but they are here relatively more slender and elongate than in *C. aberrans* and *absurdus.*

Cricotopus conformis Curran.

Taken at light, Yúnez River, Febraury, June; Tanamá River, March, July; Río Cidra, March; Lares, March; Quebrada Joba, March, 1935.

Cricotopus insolitus Curran.

Taken at light, Río Cidra, June; Yúnez River, February, June, August; Luquillo Mts., June; Tanamá River, March, 1935.

Corynoneura (Thienemaniella) similis Malloch.

Taken at light, Yúnez River, June, August; Río Cidra, March, 1935.

Pseudochironomus fulviventris Johannsen

Taken at light, Yúnez River, June 22; Luquillo Mts., June 10, 1935.

Chironomus *(Stenochironomus)* **furcata** n. sp.

♂. Head and antennae yellow, the scape, palpi and proboscis pale brownish. Eyes separated on the front by a width greater than the width of the dorsal process of the eye. Last antennal segment 1.5 times as long as segments 2 to 13 combined. Palpi nearly as long as the last antennal segment, its second and third segments subequal, fourth segment 1.5 times as long as the third. Thorax yellow, the two broad lateral vittae of the mesonotum, base of scutellum, metanotum except for fine median yellow line, three large angular spots on the pleura, and two large spots on the pectus, brown. Thorax produced

over the head and pronotum reduced as in Stenochironomus. Abdomen yellow, the larger part of the first and the apical third or half of third to sixth, and larger part of the remaining tergites brown. Spur of the ninth tergite long and slender the tip extending caudad to tips of the inferior and superior appendages, the latter slightly enlarged apically with strong anteriorly directly bristles and one long posteriorly directly bristle; the superior appendage enlarged and bristly at base, slender, bare and curved apically. Dististyles bristly, longer than the basistyles, gradually widened apically, ending in a fork the inner limb of which is stout, blunt, and thumb-like, the outer limb longer more slender and tapering to a point on which a long slender bristle is placed. Legs yellow, fore tarsi not bearded, fore basitarsus 1.2 times as long as the tibia; pulvilli well developed; fore tibiae with rounded scale; middle and hind tibiae each with two strong spurs on normal combs. Wings hyaline with pale veins including crossvein; the radius ends as far in front of the apex of the wing as the media does behind it; cubitus forks distinctly distad of the crossvein. Squama with a fringe of several hairs. Length 3.5 mm.

Taken at light June 7, 1935. Type and paratypes from Luquillo Mts., Puerto Rico. The lack of wing bars combined with the peculiar furcate distictylesc distinguish this species from other members of the subgenus Stenochironomus. Type and paratypes, Luquillo Mts., June 7, 1935. Type in the Cornell University Collection.

Chironomus bulbosa Garry.

This species was originally described from Cuba. Guánica Lagoon, February 24; Yúnez River, June 19; Cartagena Lagoon, August 3 and 10; Tortuguero Lake, August 15.

Tanytarsus (Rheotanytarsus) meridionalis n. sp.

♂. Pale yellow, including legs, the metanotum and the three vittae of the mesonotum darker yellow. It is probable that in life the abdomen, at least, is somewhat greenish. Eyes separated on the vertex by a distance subequal to the width of the dorsal extension of the eye. Antennal segments 2 to 13 combined about 1.75 times as long as segment 14. Hypopygium closely resembling that figured in New York State Museum Bulletin No. 86, plate 33, 4; the apical fifth of dististyles curved down, about a fourth as wide as the dististyles near the middle; dorsal spur of ninth tergite acute, ending a little distad of apex of basistyle; inferior appendages slightly clavate ending beyond tip of the spur, with the usual strong curved bristles; superior appendages shorter, ending little if any distad of apex of basistyle, apical and distinctly broader than toward the base with a few fine erect bristles; brush slightly shorter than superior appendages, with apical half or two-thirds with flattened blade-like hairs which are broadest at the tip. Anterior tibia with a short sharp spur, fore basitarsus about 2.3 times tibia in length; middle and hind tibiae each with two combs which are separated from each other at the base by a distance nearly half the depth of the comb; each comb with a long, sharp, slightly

curved spur; pulvilli vestigial; empodium small. Wings hyaline with pale veins; rather densely hairy; posterior branch of radius ends but very slightly distad of anterior branch of the cubitus; media ends in the tip of the wing; cubitus forks far distad of the short cross vein. Length 1.70 mm, wing 1.25 mm.

♀. In coloring like the male. Antennae seven segmented, the second and third more or less fused, the intermediate segments spindle-shape, without distinct necks, the last segment slender, scarcely twice as long as the next to the last. Ratio of fore tibia to basitarsus as in the male. Wing slightly broader than in the male. Length 1.25 mm. Wing length 1.25 mm.

This species differs from the North American *T. exiguus* Joh. and from the South American *T. abbreviatus* Kieff, in the relatively longer fore basitarsus and the relatively shorter terminal antennal segment in the male.

Type and paratypes from Yúnez River, August 14, 1935. Other localities: Río Cidra, March 23; Luquillo Mts., June 10; Tanamá River, March 12; Quebrada Jobo, March 7; Tortuguero, March 19, 1935. Type and paratypes in the Cornell University Collection.

Ceratopogon (Brachypogon) impar n. sp. (Ceratopogonidae)

♀. Thorax including scutellum and metanotum black, slightly cinereous, notum sparsely short bristled; abdomen yellow, third and fourth tergites each with a pale brown median transverse band interrupted and darker in the middle; fifth and sixth tergites show a trace of an interrupted band in the form of two dark spots place side by side; apex dark; venter yellow. Antennae yellow, scape dark. Legs yellow, basal half of fore and middle femora and extreme apex of all of these, dark; claws equal. Wings milky, without microtrichia; apex of radial veins fused into a conspicuous dark stigma ending about the middle of the wing but slightly distad of the level of apex of Cu_2; media ends slightly behind apex of wing. Halteres pale. Length 0.8 mm in alcohol; wing 0.7 mm.

The coloring of the abdomen and legs seems to be subject to some variation since in the paratype the paired marks on the abdomen are fused on the middle line and the middle and hind tibiae are slightly darkened in the middle section.

This species differs from the European *C. vitiosus* in coloring and in the relatively shorter radial veins. Type from El Yunque trail, June 10, 1935; paratype from Luquillo Mts., June 7, 1935. In the Cornell University Collection.

Paltostoma agyrocincta Curran (Blepharoceridae).

Sabana River, March 7; Luquillo Mts., June 7; La Mina Recreation Area, July 14; El Yunque Trail, July 27.

Key to North American species of Maruina (Psychodidae)

(Based largely on descriptions)

1. Basal sections of R_3 and M_2 obliterated and lacking hairs; wing narrow lanceolate, about four times as long as wide; R_5 originates distad of the level of the base of M_3; hairs of body and wings brown, hair tufts on thorax and wing base blackish brown. Puerto Rico----*hirta* n. sp.
   Basal sections of R_3 and M_2 distinct, or differing in other characters----- (2)
2. Thorax with black or brown hairs; antennae three-fourths as long as width of wing; legs black, basitarsi white; ventral plate elongate, narrowed toward the base. Length of female 2 mm. California and Washington--*lanceolata* Kinkaid
   Thorax largely with yellow hairs-------------------------------------- (3)
3. Legs uniformly blackish brown; wing with blackish hair, basal part to the fold with whitish hair. Male. Maryland------------------*nuda* Dyar
   Legs more or less pale-- 4
4. Antennae nearly as long as the body, segments beyond the second over three times as long as broad; petiole of R_{3+4} less than half as long as the cell R_3; petiole of M_{1+2} less than a fourth as long as the cell M_1; body and legs covered with yellow hairs; length 1 mm. Female. Mexico--*cirrata* Coq.
   Antennae shorter; wing with white tuft at tip----------------------- 5
5. Hair of abdomen pale, slightly mixed with blackish; wing uniformly covered with black hair; length 1 to 1.25 mm. Female. St. Vincent Island --*angustipennis* Will.
   Hair of abdomen darker, clothed with short black and white, and longer dark hair; tip of ventral plate narrow with shallow emargination and rounded lobes; wing with two transverse black bands; length of wing 2.5 mm, breadth 0.45 mm. Arizona----------------*unipunctata* Haseman

Maruina californiensis Kellogg cannot be included here since only the immature stages are known. The species *californica* Kinkaid does not belong to the genus Maruina; *M. cirrata* is placed in the genus on the authority of Dr. Dyar.

Maruina hirta n. sp.

♂. Hairs on head, body and wings coarse, flattened, scale-like. Hairs on head brown with blackish-brown tufts on each side above the eyes; slender hairs on first basal and on the seven apical antennal segments pale brown, the remaining antennal segments shaggy with somewhat broader, closely crowded blackish-brown hairs. Antennae 0.6 mm long, the segments short ovate, without distinct necks. Eyes separated on the vertex by nearly three times the width of the eye-bridge. Ground color of thorax and abdomen pale; a dense tuft of blackish hairs anteriorly on mesonotum on each side, remainder of thorax, abdomen and legs more sparsely covered with brown hair. Tarsi pale, sparsely short haired, apical segment dark. Each wing with a dense tuft of long, blackish-brown scale-like hairs on the costa proximad of the fold and another tuft of the same size just distad of the fold, wing veins with long brown hairs, costal and hind

margin with a dense fringe of long brown hairs, that on the hind margin measuring 0.6 to 0.7 mm in length. The wing membrane as seen in the denuded wing is tinted pale brownish with a hyaline patch distad of the middle and more or less hyaline basally, in cells R_5, M_{1+2} and the anal angle. The venation somewhat resembles that figured by Haseman (1907) for *M. unipunctata* Has. but the bases of R_3 and M_2 are obliterated. It resembles still more closely that figured by Müller for *M. pilosella* Müller (1895) differing in that R_2 is about as long as the petiole of R_4 and R_5, and also that the interruption at the bases of R_3 and M_2 is more extensive. Wing about four times as long as wide, apex acute as in *M. unipunctata.* The halteres are pale.

The hypopygium is of the usual Psychodid type; minor appendages hairless, well developed, the basal segment more or less cylindrical, more than twice as long as wide, the apical segment a little shorter, but more slender and tapering to the apex. Basal segment of major appendages pear-shaped, basally with twenty or more long, slender, erect hairs; apical segment about .035 long, capitate, the head-end with small dark scales, the petiole much attenuated and bare. Last sternite (dorsal in position) slightly longer than broad, parallel sided, apex truncate with rounded angles. Ninth tergite (ventral in position) slightly broader than long with median somewhat truncated lobe between the short, rounded lateral lobes. Length of insect 1.6 mm; wing lenth 1.3 mm.

♀. Like the male except for sex characters. The palpi are 0.3 mm long, the apical segment 0.125 mm. The shaggy tuft of densely placed hairs on the basal antennal segments so conspicuous in the male is lacking.

The holotype from the Guaynabo River, Puerto Rico, February 21, 1935; allotype and paratype from the Yúnez River, June 20, 1935.

Larvae and pupae collected at the same time and place resemble those of *Maruina californiensis* Kellog (1901). In the Cornell University Collection.

STUDIES OF THE ROOT SYSTEM OF COFFEA ARABICA L.

Part I.—Environmental Condition Affecting the Distribution of Coffee Roots in Coloso Clay

By J. Guiscafré-Arrillaga and Luis A. Gómez

Introduction

To the present, the aerial portion of plants have been more intensively and thoroughly studied in botanical and agronomic problems. The reasons for this are obvious, among the most important being that it is the part from which man usually derives more income and the easier on which to undertake investigations.

However, knowing that production in the tops of plants depend on the roots and particular environmental soil conditions it is clear that studies of the root system help a great deal the technologist and agronomist in the efficient performance of agricultural practices, such as systems and distances for planting, fertilizer application, general tillage operations, drainage and irrigation systems, control of diseases and erosion, intercropping and others of special application to particular crops, all of which contribute to a more productive aerial portion.

With these objectives in view and to obtain fundamental knowledge on which to base investigations and recommendations for necessary agricultural practices in the growing of coffee, this study was undertaken.

Literature Review

The distribution of roots of crop plants in the soil and related problems have been studied by Gómez (1), Lee (2), Lee and Bissinber (3), Nutman (4), (5), (6), Trench (7), Venkatraman (8), Weaver (9), Weaver and Christ (10). These investigators have devised and used various methods for the most accurate determination of the root system under study. Such methods may be classified as natural and artificial. Those methods in which specially designed boxes or cylinders are used for growing the plant the root system of which is to be studied, may be termed as artificial while the methods of excavating and weighing the roots of plants as they actually occur at different soil depths, or that of exposing and fol-

lowing the roots by washing with jets of water or loosening the soil with hand tools and drawing the root system to scale in the field, may be classified as natural.

The artificial method: This has been used by Lee (2) and Venkatraman (8). The method followed by Lee (1) consisted in planting gsuar cane seeds in boxes with detachable sides and poultry netting wire placed horizontally and filled up with soil at different depths. Once the plants had attained the desirable size, the soil was washed away and the roots exposed but held in their correct position by the horizontally placed poultry netting. In this way the distribution of the roots at different depths was determined. Lee (2) originated a more natural and accurate method later.

Venkatraman (8) used earthenware cylinders in which cane seeds were planted for studying the root distribution.

Natural methods: The following investigators have used the "natural methods" for the study of root systems of plants: Lee (2), (3), Gómez (1), Nutman (4), (5), (6), Trench (7) and Weaver et al. (9), (10).

The method used by Lee (2), Lee and Bissinger (3), while making studies of the root distribution of sugar cane in Hawaii and the Philippine Islands may be described as follows: after selecting 5 to 10 stools as uniform as possible in a commercial field, the cane is cut and the green and dry weights of the tops determined. Stakes are set exactly half way between the rows of cane to be studied and the contiguous rows on both sides. A cord is stretched around the four stakes enclosing the cane stools under study. Then the excavation is begun within this area and all soil removed to a depth of 8 inches care being taken that the excavation does not exceed 8 inches in depth. As the earth is removed from the area studied, it is thrown in a wire screen of ¼-inch mesh placed at one side of the excavation. The screen separates the roots from the soil. All the roots found in the top-most 8-inch layer represent the mass of roots of the 5 or 10 stools in the top-most 8 inches of soil. The roots from the top-most 8-inch layer are then collected in bags, labelled and held until the complete excavation has been made. Deeper excavations are then started and the roots separated for every 8-inch layer until the desired depth is attained, which is usually that point where the quantity of roots found is negligible. The roots from the various soil levels are then washed, separately air-dried, and oven dried, until all moisture is removed and weighed.

Following this method which is very accurate, the distribution of roots at various soil depths is determined with certainty. Lee (2), (3), prefers this quantitative method to the expensive, and almost impossible task of longitudinal measurements since the weights of roots may possibly be even better index of the absorbing surfaces.

Gómez (1) followed Lee's method for the study of the distribution of sugar-cane roots in certain soil types of Puerto Rico.

Nutman (4), (5), (6) has studied the root system of coffee, *Coffee arabica* L., in various soil types of British East Africa using various methods.

Where water was readily available Nutman studied the root system of coffee by washing the soil with fine jets of water under pressure. The soil was washed in layers and the roots exposed and followed to their terminations. The roots were pegged in their position on the soil face by means of long, pointed steel rods. When the roots of the whole selected sector were washed out, and the roots pegged in their natural positions a string grid of 1 ft. mesh was then erected and the root system drawn to scale in the field. Where water was not available, excavation was performed by hand with the help of hammers and chisels.

But Nutman (6) used furthermore the following method which he claims to be more accurate. This consists in digging a trench with one face 8 to 9 inches from the trunk of each experimental tree. The soil is then washed away in adequately measured 1 ft. cubes by a jet of water of ½ inch diameter and 10 pounds of pressure. The soil washed is examined and all roots from each cube are collected, washed, labelled and preserved. Then all the feeding roots are measured from a selected section of the root system. In this way it is determined by trees the distribution of the feeding area at various soil depths.

In addition Nutman (5) has studied the effect on the coffee root system of various soil conditions, such as presence of hardpans, aeration, height of the water table, soil reaction, manurial treatments and cultivation methods.

Trench (7) after studying the root system of coffee trees in Kenya carefully removed by washing, comments that the root system of coffee can be materially affected by environmental factors and that it can be modified by wise guidance and suitable treatments for proper development.

In the United States of America, Weaver and his associate (9), (10) have studied intensively the root systems of numerous plants

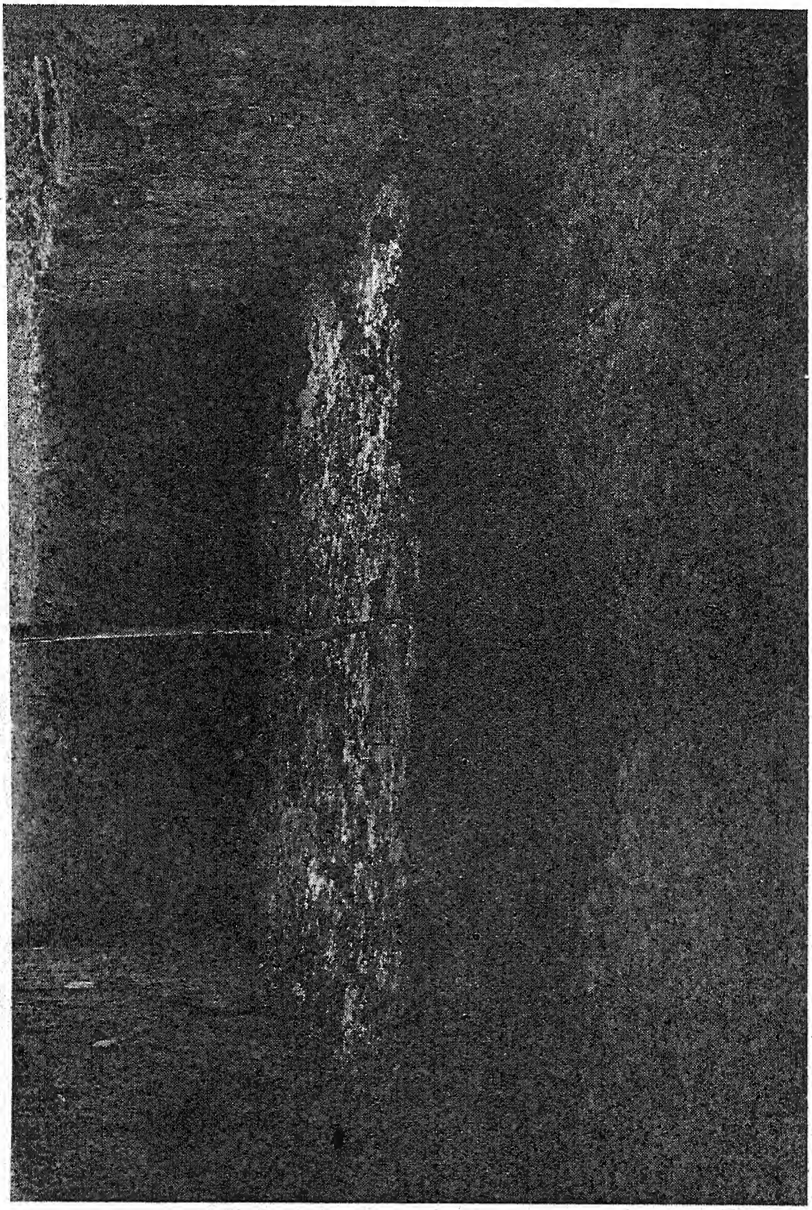


PHOTO. No. 1. Method of excavation; every block represents one cubic foot of soil.

in various regions of that country. His method consists in working into the side of a trench with hand tools and folowing up the roots by breaking away the soil. Once exposed, the entire root system is drawn to scale in the field.

After a critical study of the work done and the results accomplished by the investigators just mentioned, the writers developed a new method which is really an outgrowth of the methods developed by Lee (2), (3), Gómez (1) and Nutman (6) but which is thought to be more adaptable for the study of the root system of coffee in our prevailing soil and climatic conditions.

Before going into the details of the method used in this preliminary study, an account will be given of the conditions of the trees studied and their environment.

Conditions Relative to the Soil and Coffee Trees Studied on a Representative Soil Type of Puerto Rico

The six coffee trees selected for this study were located at the farm of the College of Agriculture and Mechanic Arts at Mayagüez, P. R.

These trees were growing in a 2-acre terrace of soil belonging to the Coloso Clay type and surrounded on two sides by a small stream and hills of low elevation of Catalina Clay. The Coloso Clay found in this terrace originated from alluvial and colluvial deposition of the stream and the neighboring hills. Terraces of this nature and soil type are quite abundant in the coffee region of the island. The drainage of this soil is poor during the rainy season due to the high level of the water table. This soil has been found to be quite productive when proper drainage systems are made. The physical and chemical analyses of this type of soil are shown in tables III and IV. The average annual rainfall for this region is 81 inches.

The six coffee trees used for this study were 7 years old. The average size of these trees was 299.16 cms. high, 159.66 cms. wide and of a trunk diameter of 3.70 cms. The individual sizes of all trees is shown in table VIII. The general vegetable conditions of the trees is shown by tree No. 6 in plate 3. All the trees studied belong to the arabian coffee type, *Coffea arabica* L., which is the coffee variety extensively planted in the island.

The general conditions of the field where the excavation was performed may be described as follows: The coffee trees were planted systematically in rows at 8 ft. × 8 ft. under leguminous shade trees

of "guaba", *Inga Inga* (L.) Britton, and "guamá", *Inga laurina* (Sw.) Willd., planted at an approximate distance of 16 ft. × 16 ft. The agricultural operations effected rearly consisted in weeding with a "machete" two or three times, and pruning the shade lightly after picking the crop. No fertilizer was ever applied to the trees in this field.

The excavations of the root system were started on February of 1937 and finished on May of the same year. The trees were in bloom when the tops were cut off.

Method of Procedure

For this study, six contiguous trees were selected in one of the innermost rows of the field. The tops were cut close to the soil surface and the green weights of the stems, leaves and lateral branches were obtained by direct weighing in the field. The dry weights of these same parts were obtained later after drying in the sun and in electric ovens. Table VIII shows the green and dry weights of each tree.

Once the tops were removed, stakes were placed halfway between the row of coffee trees to be studied and the neighboring rows on both sides. A cord was stretched around these stakes thus marking a total area of 384 sq. ft. equivalent to an area of 64 sq. ft. corresponding to each of the six trees. The position of the stakes, the top-most total area excavated and the planting distance of the trees is shown in text figure No. 1.

The area corresponding to each tree was then divided in squares of one sq. ft. each by means of 5-inch nails and cords. The excavation was begun, and the soil was removed in blocks of exactly one cubic foot in the 64 sq. ft. area corresponding to each tree. The depth of excavation was carefully checked with a 12-inch hand ruler. The roots found in each cubic foot excavated per tree and per layer were separated from the soil by a wire screen of ¼ inch mesh and by hand. The roots found were collected in cloth bags and taken to the laboratory where they were washed and spreaded under shade until the excess of water was evaporated. Then the green weights were determined. Afterwards the roots found in each cubic foot were dried in electric ovens to determine the dry weights. The same was done with a second layer to a depth of 24 inches, with a third layer to a depth of 36 inches, and to a fourth layer to a depth of 48 inches, in which layer the amount of roots found was very small. Details

concerning the excavation and separation of the roots from the soil are shown by plates Nos. 1 and 2.

The excavation by cubic foot was controlled by an excavation map specially prepared for the total area to be excavated for each tree, by numbering each block. The excavation map of the root system of the six trees used for the four layers excavated by blocks of one cubic foot each is shown in text figures Nos. 3, 4, 5, 6, 7 and 8.

It was possible to make the excavations by blocks of one cubic foot due to the stiffness of the clay contained in the soil. It is realized that in loose soils this method is impracticable, but it is claimed to be the most accurate method for the study of root systems in clay soils because it makes possible to determine not only the quantities of roots at different soil depths but also the distribution of the roots in definite lateral areas. In other words, this method determines the lateral spread as well as the vertical penetration of the roots studied.

It is expected that some of the roots of the trees under study have extended on both sides beyond the excavations limits, but in a field planted at uniform distances, the loss of roots beyond the limits of the excavation are compensated by the roots of the trees of the neighboring rows which extend into the excavation. This idea advanced by Lee (2), (3) is applicable to systematic root studies in fields planted out at uniform distances; the types of field that should be used in studies of this nature.

The two major handicaps in the execution of this study were, the search for a systematic plantation, which are still few in the island and the separation of the coffee roots from the roots of neighboring shade rtees, as all coffee is grown under shade in Puerto Rico. This separation was possible by a thorough study, previous to the excavation of the rot systems under study, of the roots of coffee, and the shade trees in the vicinity. The morphology, color and odor of the coffee roots is typical, but in order to avoid any errors, as the separation of the roots from the soil was done by laborers, the roots found in each cubic foot excavated were thoroughly inspected by the writers and the roots of the shade trees discarded.

The writers also admit that the green weights of the roots are not completely accurate. There is the possibility for some water to be lost, thru the necessary handling during the excavation, separation and weighing, but if care is taken to perform under shade all the operations involved in the excavation, separation, washing and drying until the excess of water brought in by the washing is re-

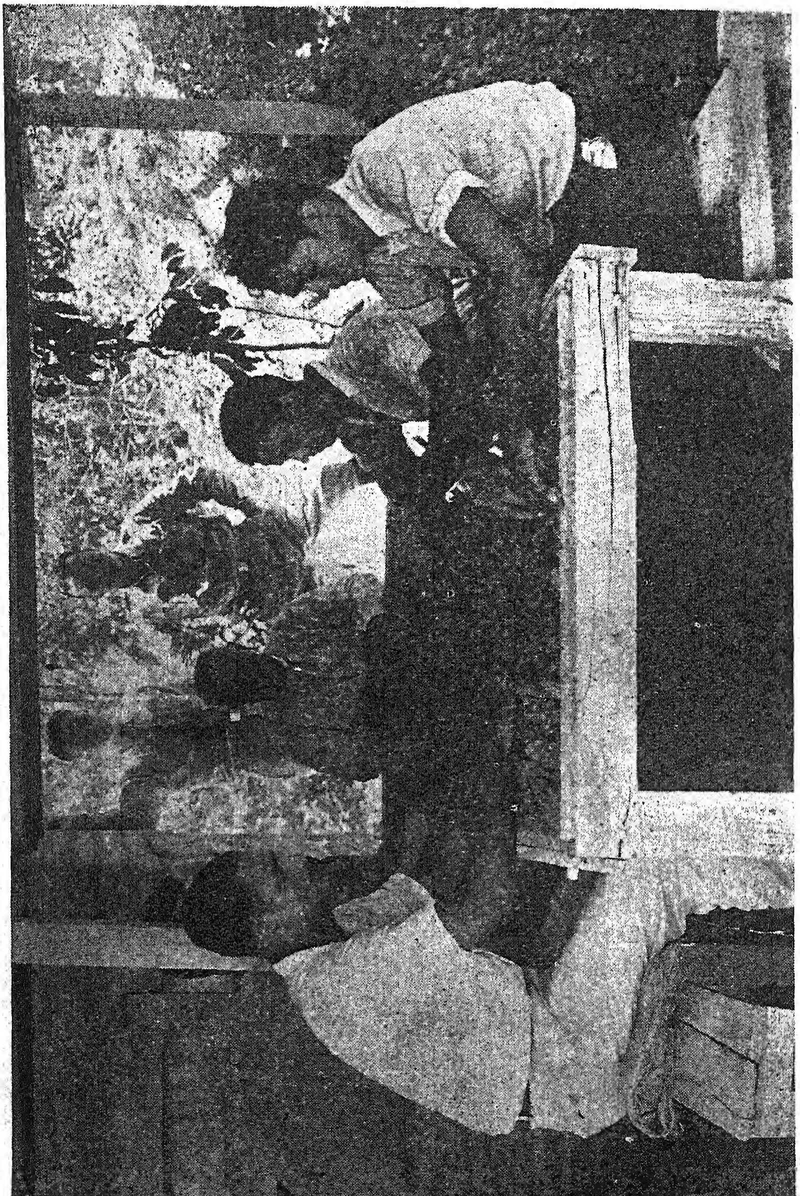


PHOTO. No. 2. Method of screening roots as the different blocks of soil were excavated.

moved, it most be realized that there is accuracy in the method used for the determination of the green weights. Although before starting the study, the difficulty involved in the determination of the green weights of the roots was appreciated these were obtained in order to compare the ratios of tops to roots based on the green and dry weights of both parts of the trees.

RESULTS

NINETY-FOUR PERCENT OF THE COFFEE ROOTS WERE FOUND IN THE TOP-MOST 12 INCHES OF SOIL:

That 94 percent of the roots were present in the top-most 12 inches of soil is shown by the following tables I and II in which the greatest quantity of roots of each of the six trees was found in the top-most 12 inches of soil.

The quantity of roots decreases tremendously from the 12-inch level downward to the depth of 48 inches at which the quantity of roots found was negligible. A small amount of roots was found for trees Nos. 3 and 6 at a depth of 48 inches. According to the figures, it is shown that 94 percent of all rots was found in the top-most 12 inches and that practically the whole root system of seven-year old coffee trees growing in Coloso Clay is found in the first 24 inches of soil, since 99 percent of all the roots of the six trees under study were excavated above the 24-inch level. (see Photos. 4 and 5.)

THE PERCENTAGE OF ORGANIC MATTER IS HIGH IN THE COLOSO CLAY TOP-SOILS:

There was 2 percent of organic matter in the top-most 12 inches of soil as indicated by table III. This is remarkably high for Puerto Rican soils. The quantity of organic matter decreases tremendously at lower depths. The high content of organic matter in the first layer is undoubtly due to the acumulation of leaves and other vegetable remains of the coffee, shade trees and weeds. The high content of organic matter may have a direct influence on the development of more roots at the surface, although the effect of better aeration of surface layers is also a factor to be considered.

As shown also by table III, the percentages of silt and clay was practically the same at all soil levels while the percentage of total sand was greater at the 36 and 48 inch level.

The high percentage of clay, and average of 72 percent, makes this a distinctly clay soil.

TABLE I

DISTRIBUTION BY WEIGHT OF ROOTS OF COFFEE TREES, 7 YEARS OLD, IN COLOSO CLAY SOIL AT DIFFERENT SOIL DEPTHS

Layers	Depth	Tree I	Tree II	Tree III	Tree IV	Tree V	Tree VI	Total weight of roots per layer
		Grams	Grams	Grams	Grams	Grams	Grams	Grams
1st	0″–12″	162.8570	288.5323	199.9569	114.2361	179.8376	229.7501	1175.18
2nd	12″–24″	4.3731	10.7888	11.3501	5.5535	16.0142	15.1872	63.26
3rd	24″–36″	0.1176	1.0372	0.2637	0.9622	0.9378	5.4049	8.72
4th	36″–48″	0.0000	0.0000	0.6521	0.0000	0.0000	0.0154	0.67
Totals	48″	167.3477	300.3583	212.2228	120.7518	196.7896	250.3576	1247.83

Underscored figures indicate highest concentrations of roots.

TABLE II

TOTAL DISTRIBUTION OF COFFEE ROOTS PER LAYER AT DIFFERENT SOIL DEPTHS

Depth of excavations by layers		Roots in each layer	
		Grams	Percent
1st layer	0″–12″	1175.18	94.17
2nd layer	12″–24″	63.26	5.07
3rd layer	24″–36″	8.72	0.70
4th layer	36″–48″	0.67	0.05
Total	48″	1247.82	99.99

TABLE II.

PHYSICAL ANALYSES OF SOIL AT DIFFERENT DEPTHS

Depths	Wet sieving method Percentages						Bouyoucos' method Percentages		
	Organic matter (1)	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand (2)	Total sands	Silt	Clay
0″–12″	2.00	0.25	0.53	1.60	4.30	2.12	8.80	16.80	74.40
12″–24″	0.80	0.16	0.18	0.25	0.87	5.34	6.80	18.40	74.80
24″–36″	0.50	2.20	1.80	1.70	3.50	8.00	17.20	14.40	68.40
36″–48″	0.58	1.70	1.60	1.60	4.20	4.50	13.60	18.80	67.60

(1) Determined by Schollenberger, La Motte method.
(2) Figures of very fine sand were obtained by subtracting sum of fine graved, coarsesand, Medium sand and fine said from total sands.

TABLE IV

CHEMICAL ANALYSES OF THE SOIL EXCAVATED AT DIFFERENT DEPTHS

NUTRIENT DISTRIBUTION BY LAYERS—PERCENTAGES OF SOIL WEIGHT

Layers depths	Soil reaction pH	Nitrogen N	Phosphoric acid P_2O_5	Potash K_2O	Lime CaO	Magnesia MgO	Silica SiO_2	Aluminum Al_2O_3	Iron Fe_2O_3	Manganese MnO	Percent moisture
0″–12″	4.60	1.490	0.100	1.400	0.53	0.955	68.440	12.775	7.230	0.080	24.92
12″–24″	4.65	0.905	0.035	1.625	0.52	0.700	69.415	14.830	5.655	0.065	22.26
24″–36″	4.60	0.670	0.105	1.615	0.44	0.655	65.980	8.885	15.115	0.100	22.88
36″–48″	4.77	0.680	0.115	1.750	0.40	0.635	63.785	7.435	18.420	0.105	21.67

Underscored figures indicate higher concentration of nutrients.

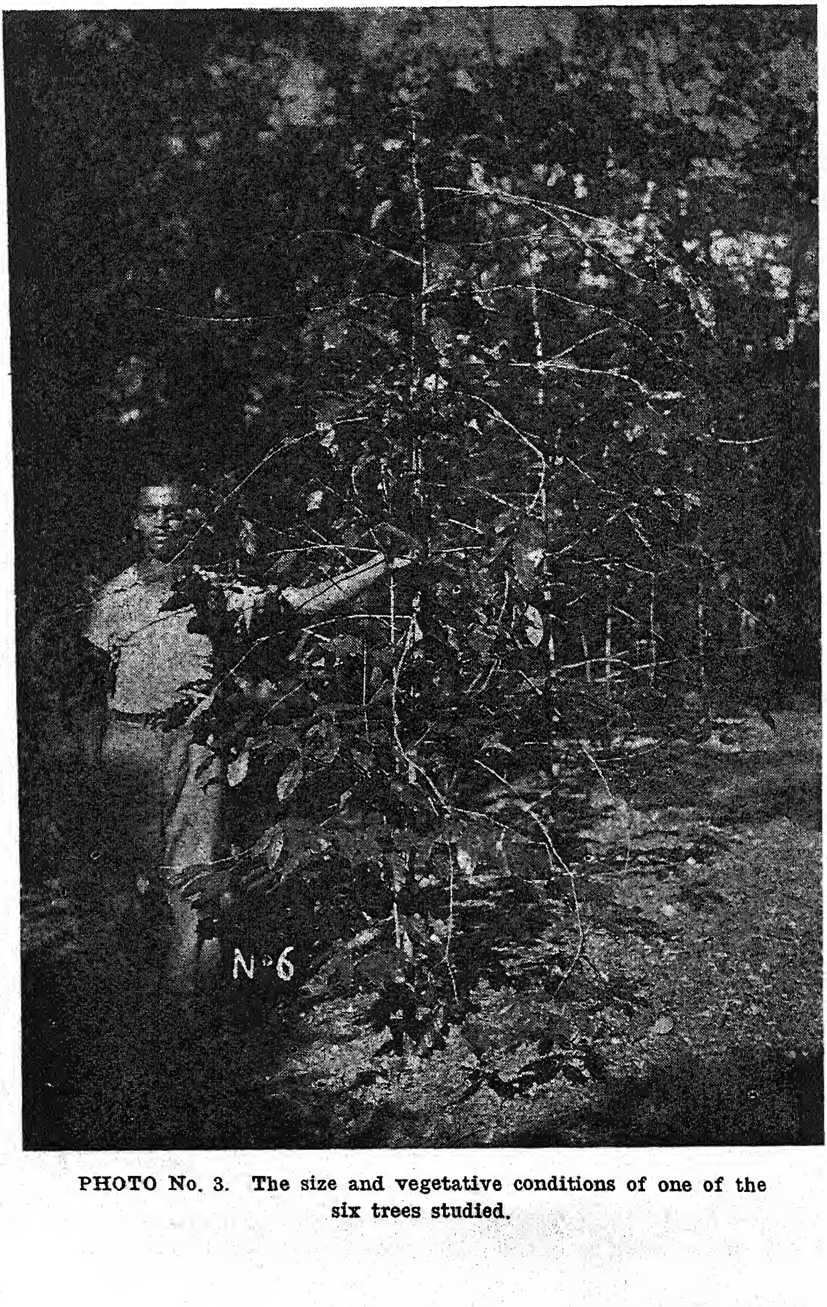


PHOTO No. 3. The size and vegetative conditions of one of the six trees studied.

THE PRINCIPAL PLANT NUTRIENTS ARE PRESENT IN FAVORABLE QUANTITIES AT THE SOIL LEVELS STUDIED:

Upon examination, table IV shows that the nitrogen and potash are present in rather high quantities, while phosphorus is present in low quantities. The quantity of these three nutrients is practically the same at all depths.

The pH, on the average 4.6, indicates that the soil reaction is decidely acid. The content of calcium was extremely low and as well as the pH, was practically the same for all soil levels. The iron was present in higher quantities at the 36 and 48-inch levels while alumninum was present in lower amounts at these same levels.

The percentage of moisture although higher at the first layer was practically the same at all the other soil levels studied.

Magnesia is present at all soil depths in greater quantities than calcium.

In general, according to the chemical analysis shown by table IV, the Coloso Clay is a good soil. It has proved to be productive for sugar cane growing specially in dry years and when using the "gran banco" system of planting which provides adequate conditions of drainage.

In text figure 2 the distribution of the coffee root system is shown in relation to the root weight and physical and chemical soil analyses of the different soil layers.

A HEAVY TOP IS NOT DEPENDENT ON A STRONG AND HEAVY ROOT SYSTEM:

In tables V and VI is shown the advantages of the new method used for this study.

In table V, in the first layer, of the 384 cu. ft. excavated for the six trees, only 242 cu. ft. were found with roots and the number of cubic feet found with roots decreased enormously in the other three layers. In the fourth layer, of 384 cu. ft. excavated, only 4 cu. ft. were found with roots and these belonged to the root systems of trees Nos. 3 and 6. Text figures 3 to 8 show the advantages still more clearly since in the excavation maps for each tree, the lateral extension and vertical penetration of the roots is indicated by the dry weights of the roots found in each cubic foot excavated. Upon examination, each individual excavation map shown in text figures 3 to 8, gives an aproximate idea of the form of the root

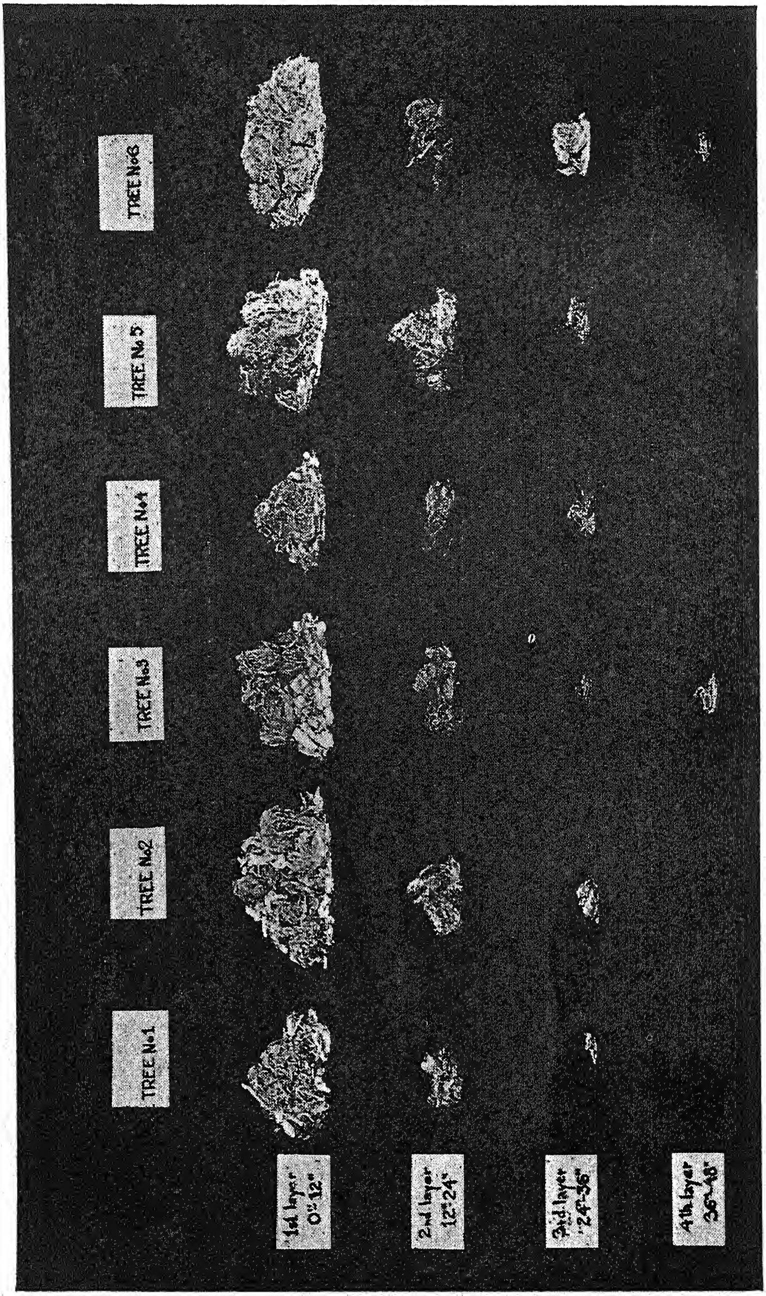


PHOTO No. 4. Quantitative distribution of roots found per tree and per layer in the six coffee trees studied.

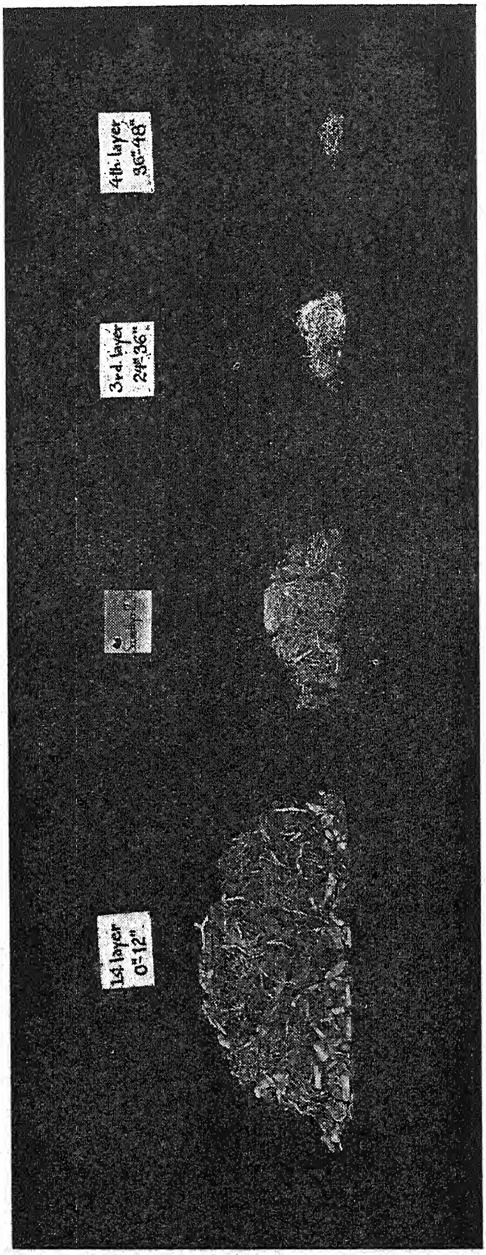


PHOTO No. 5. Total amount of roots found in the different layers of the six coffee trees in this study.

system of each 7-year-old coffee tree in this type of soil. According to the dry weight of roots found per cubic foot per tree and to the position of the blocks of soil found with roots, the form of the root system is that of an inverted cone of rather short height. It is also shown in text figures 2 to 8 that the vertical penetration of the root system is 4 feet and the lateral extension is approximately 4 feet also.

TABLE V

DISTRIBUTION OF ROOTS AT DIFFERENT SOIL DEPTHS IN RELATION TO TOTAL VOLUME OF SOIL EXCAVATED AND TO VOLUME OF SOIL WHERE ROOTS WERE PRESENT

QUANTITIES OF ROOTS, DRY WEIGHTS

Layer depths	Total weight of roots per layer of six coffee trees	Total cubic feet excavated per layer	Weight of roots per layer per cubic foot	Cubic feet excavated where roots were found	Weight of root per cubic foot where roots were found
	Grams		Grams		Grams
0″–12″	1175.18	384	3.060	242	4.86
12″–24″	63.26	384	0.140	103	0.61
24″–36″	8.72	384	0.020	35	0.32
36″–48″	0.67	384	0.002	4	0.17
Total	1247.83	1536	....	384	....

In table VI, is shown that of a total of 256 cu. ft. excavated for each of the six trees studied, the number of one cubic foot blocks containing roots fluctuate between 51 and 76 blocks.

The trees with the heaviest root systems, Nos. 2 and 6, do not have the most extensive root systems since all their roots were found in 65 and 57 one-cu. ft. blocks respectively. If table 8 shown later is examined, it will be noticed that trees Nos. 2 and 6 do nót possess the heaviest tops.

TABLE VI

WEIGHT OF ROOTS PER CUBIC FOOT OF SOIL PER TREE

Tree number	Dry weight of roots per tree	Total cubic feet excavated per tree	Weight of roots per cubic foot	Cubic feet where roots were found	Weight of roots per cubic foot where roots occurred
	Grams		Grams		Grams
1	167.35	256	0.65	62	2.70
2	300.36	256	1.17	65	4.62
3	212.22	256	0.82	73	2.90
4	120.75	256	0.47	51	2.37
5	196.79	256	0.77	76	2.59
6	250.36	256	0.98	57	4.39

With the exception of tree No 4 the figures for the dry weights of tops and roots and number and position of the one-cubic foot blocks excavated for each tree found with roots, indicate that a heavy top growth is not dependent on a heavy and extensive root system. This is in accord with Lee's (2), (3) and Gómez (1) investigations on the root systems of sugar cane in Hawaii, the Philippine Islands and Puerto Rico.

THERE IS NO FIXED RATIO OF TOPS TO ROOTS IN COFFEE TREES:

Studying the figures for green and dry weights of tops to roots ratio since it is different for all the six trees studied. Based on the total dry weights of the tops and roots of all trees, the ratio of tops to roots ratio is 7. Inasmuch as these figures are practically equivalent it may be stated that the ratio of tops to roots is aproximately 8, taking in consideration either the dry or green weights of both parts of 7-year-old coffee trees.

In table VII information is given also regarding fertilizer applications and moisture conditions of the six trees studied.

THE TRUNK DIAMETER OF COFFEE TREES IS A GOOD INDICATION OF A HEAVY TOP AND A STRONG ROOT SYSTEM:

In order to understand clearly the possible interrelationships between certain botanical characteristics of the tops and roots of the trees studied, table VIII was prepared.

This table shows the following:

(*a*) That the average tree size for the trees used in this study has a height of 299.16 cms., almost 10 ft.; 159.66 cms. or 5 ft. 4 in. of lateral spread and a trunk diameter of 3.70 cms., approximately 1½ in.

(*b*) That the average tree top and root system in this series weighed 1849.16 grs. and 207.97 grs. (dry weight) respectively.

(*c*) That the trunk diameter of coffee trees was more indicative of a heavy top and a strong, extensive, root system than either the height or lateral spread. The figures in table VIII show this clearly; the trees with a trunk diameter of 4 cms. or above are in general the trees having the heaviest and most extensive root systems. For comparing the root extensiveness of the six trees, refer to table VI.

TABLE VII

RATIO OF TOPS TO ROOTS OF EACH TREE BASED ON GREEN AND DRY WEIGHTS AND ITS RELATION TO MOISTURE AND FERTILIZER

DRY WEIGHTS

Tree number	Fertilizer applied	Average per-cent of soil moisture for all layers	Tops	Roots	Ratio of tops to roots
			Grams	Grams	
1	None	22.93	1,642.00	167.35	9.81
2	None	22.93	2,038.00	300.36	6.78
3	None	22.93	1,925.00	212.22	9.07
4	None	22.93	1,471.00	120 75	12.18
5	None	22.93	2,094.00	196.79	10.64
6	None	22.93	1,925.00	250.36	7.68
Totals			11,095.00	1,247.83	8.88

GREEN WEIGHTS

Tree number	Fertilizer applied	Average per-cent of soil moisture for all layers	Tops	Roots	Ratio of tops to roots
1	None	22.93	2,500.00	338.09	7.39
2	None	22.93	3,500.00	591.81	5.91
3	None	22.93	3,100.00	404.08	7.67
4	None	22.93	2,050.00	263.98	7.76
5	None	22.93	3,400.00	396.95	8.57
6	None	22.93	3,100.00	526.28	5.89
Totals			17,650.00	2,521.19	7.00

TABLE VIII

SIZE, GREEN AND DRY WEIGHTS OF THE TREES STUDIED

Tree number	Height	Lateral spread	Trunk diameter	Uprights (1)		Laterals (2) and leaves		Tree tops (3)		Roots	
				Green weight	Dry weight	Green weight	Dry weight	Green weight	Dry weight	Green weight	Dry weight
	Cms.	Cms.	Cms.	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams
1	282	160	3.00	1200	538	1300	1104	2500	1642	338.09	167.35
2	354	194	4.00	1800	821	1700	1217	3500	2038	591.81	300.36
3	306	160	4.00	1500	708	1600	1217	3100	1925	404.08	212.22
4	242	116	3.00	1050	481	1000	990	2050	1471	263.98	120.75
5	364	124	4.50	1550	764	1850	1330	3400	2094	396.95	196.79
6	247	204	4.00	1300	708	1800	1217	3100	1925	526.28	250.36
Totals	1795	958	22.50	8400	4020	9250	7075	17650	11095	2521.19	1247.83
Averages	299.16	159.66	3.70	1400	670.00	1541.66	1179.16	2941.16	1849.16	420.19	207.97

Uprights (1) Vertical stems.
Laterals (2) Horizontal branches or fruit-bearing branches.
Tree tops (3) Uprights, laterals and leaves.

Average green weight of tops (laterals, leaves and uprights)........1849.16 grams.
" " " " laterals and leaves..................1179.16 "
" " " " uprights.........................670.00 "
" lateral spread of trees.........................159.66 cms.
" height of trees..................................299.16 cms.
" trunk diameter of trees..........................3.75 cms.
(averages determined on the basis of 6 trees studied)
Volume of excavation per tree..........................256 cu ft.
Volume excavated for all trees.........................1536 cu ft.

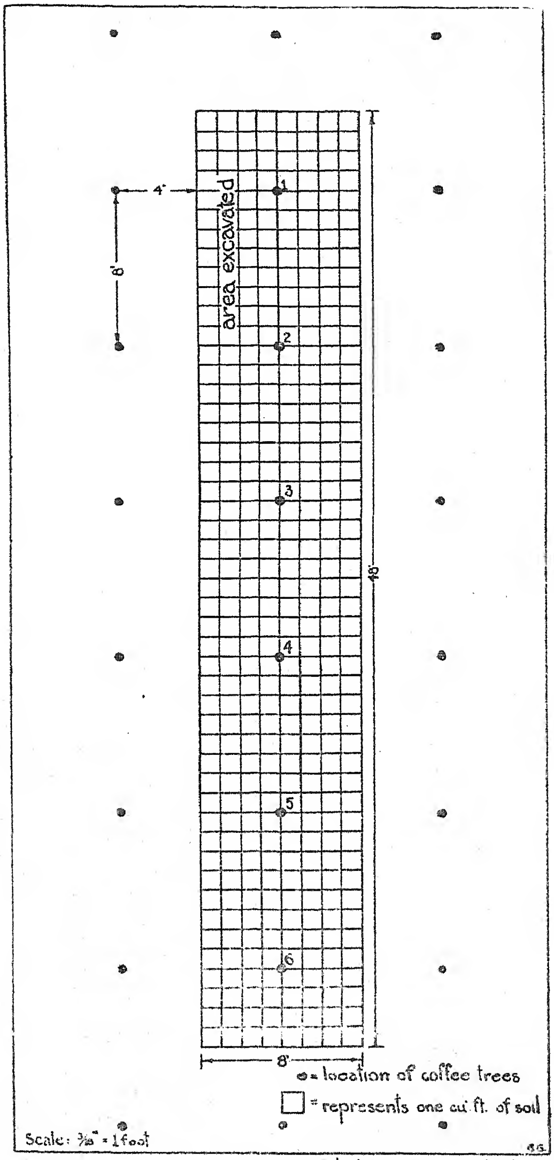
Physical analysis of soil Per cent				Quantities of roots Dry weight in grams		
Sand	Silt	Clay	Organic matter	Total weight per layer	Per cu. ft per layer	
8.80	16.80	74.40	2.00	1175.18	3.06	Soil surface – 12 inch level
6.80	18.40	74.30	0.80	63.26	0.14	12 – 24 inch level
17.20	14.40	68.40	0.50	8.72	0.02	24 – 36 inch level
13.60	18.80	67.60	0.58	0.67	0.002	36 – 48 inch level

	NUTRIENT DISTRIBUTION (Percentages of soil weight)										
	Soil reaction pH	Nitrogen N	Phosphoric acid-P_2O_5	Potash K_2O	Lime CaO	Magnesia MgO	Silica SiO_2	Aluminum Al_2O_3	Iron Fe_2O_3	Manganese MnO	Percent moisture
94.17%	4.60	1.49	0.10	1.40	0.53	0.95	68.44	12.77	7.23	0.08	24.92
5.07%	4.65	0.90	0.03	1.62	0.52	0.70	69.41	14.83	5.65	0.06	22.26
0.70%	4.60	0.67	0.10	1.61	0.44	0.65	65.98	8.88	15.11	0.10	22.88
0.05%	4.77	0.68	0.11	1.75	0.40	0.63	63.78	7.43	18.42	0.10	21.67

G.G.

Text figure 2.

Diagram showing distribution of coffee roots correlated with root weights and physical and chemical soil analyses.



Text figure no. 1: Shows area excavated for the quantitative determination and distribution of the root system of *C. arabica*, L.

Other information that can be obtained from table VIII is in relation to the water contents of uprights, lateral and leaves and roots. Based on the dry and green weights, there is approximately 50 percent of water in the uprights; 23 percent in the lateral branches and leaves, 39 percent in the whole tree tops and 50 percent in the roots. The figures definitely indicated the woodiness of the coffee tree.

Discussion and Conclusions

Recognizing the necessity of fundamental knowledge regarding the root system of coffee in Puerto Rico in order to be able to introduce better agronomic methods for growing this crop and to be able to offer definite explanations for failures attained, the present study was undertaken. A new method was used endeavoring to obtain abundant as well as accurate and reliable information. This method, consists in excavating one-cubic foot-blocks of soil in definite volumes of soils corresponding to each of the trees under investigation. The green and dry weights of the roots found in each cubic foot of soil is obtained and by using an excavation map for each of the root systems, the weight as well as the vertical and horizontal distribution of the roots excavated for each tree is obtained. The method used, just mentioned is the outgrowth of methods previously used by Lee (2, (3), Nutman (6) and Gómez (1) for studying the root systems of sugar cane and coffee.

Lee (2), (3) trying to get a quantitative distribution of the roots of sugar cane at different soil levels designed and successfully executed an accurate, fast, practicable and relatively inexpensive method of studying root systems of plants which has been fully described. Using Lee's method, no roots are lost since these are carefully separated by screens and by hand as the soils is excavated by 8-inches layers at several depths. By weighing the roots excavated by layers, an accurate distribution of the roots of the plant studied at definite soil depths is obtained. However, no information is obtained as to the lateral extension of the roots. Lee's method has the further advantage that it is practicable under conditions naturally existing in commercial fields.

Gómez (1) followed Lee's method for studying the root system of sugar cane in the western part of Puerto Rico and obtained useful and practical information.

Weaver and his associates (9), (10) studied intensively the root systems of many different plants in the United States by working into the side of a trench with hand tools and following up the roots

by breaking away the soil. Once the root system is exposed, it is drawn to scale in the field.

Although Weaver's method gives information as to the vertical penetration and lateral extension of the root systems, it must be recognized that a certain quantity of small roots must be lost necessarily in stiff soil since a soil of this nature breaks out in lumps of various sizes. The loss of these small roots will affect the results obtained because no accurate information can be obtained regarding the location of the real absorbing area of the root system. Besides, the information obtained in relation to the lateral extension of the roots is not representative because the roots do not probably extend to the same distances in all directions, taking as axis the trunk of the tree and its prolongation, the central root. In other words Weaver's method gives good information if the vertical penetration and lateral extension of the principal roots of the entire root system is desired, but since a certain quantity of the roots is lost, is impossible to get the real location of the absorbing surfaces at different soil levels.

Nutman (6) has used two methods for the study of the root system of coffee in Kenya. The first is very similar to that developed by Weaver and his associates (9), (10). The second method, which according to Nutman is possibly the most accurate method for studying the root system of plants consists, briefly, in washing away the soil in 1 foot cubes with fine jets of water at a definite selected section of the root system. The roots found at each cube are washed and the total length of the feeding roots measured.

The disadvantages of this method are obvious. In computing the total feeding area for the entire root system, it must be assumed that the average diameter and concentration of the root hairs is constant, a great percentage of the total roots is ignored since only a section of the entire root system is studied and the longitudinal measurement of the feeding roots must be necessarily a complicated and expensive procedure. Nutman developed this method believing that the longitudinal measurement of the feeding roots is the best indication of the absorbing area of the tree. But that the quantitative determination by weighing the roots is as good an indication of the absorbing capacity of the root system as longitudinal measurements, was first advanced and proved by Lee (2), (3) and later corroborated by Gómez (1) and the writers. Besides, although Nutman insists on longitudinal measurements, the figure obtained with his method (6) indicate that the greatest concentration if feeding roots

occur in the top-most 12 inches of soil which definitely establishes the fact that the weight of roots at definite levels is an accurate means of determining the location of the absorbing area of the root system. This is to be expected since the concentration of large numbers of feeding roots although of small size and weight will affect the total weight of the roots found at a definite soil depth.

Nutman's (4), (5), (6) intensive works on the root system of coffee in various types of soil in Kenya, have undoubtly contributed to explain and solve important problems related with the coffee industry of that country.

Nutman (5) also studied the effects of various soil conditions in modifying the root-growth of coffee trees and found that in general, hard-pan has little effect on root development; lava, mud-stone gravel strata and high water-table cause penetration to be inhibited in greater or less degree and that the acid limit of satisfactory growth is at a pH of 5.8 to 6.00.

According to the results obtained in this study 94 percent of coffee roots of 7-year-old trees in Coloso Clay are found in the top-most 12 inches of soil. These results generally agree with Nutman's results in Kenya (6) by which he found the greatest concentration of roots in the top-most 12 inches of soil, with Lee's (2) results in which he found that sugar cane either hilled-up or in furrows, more than 85 percent of the roots were found in the top-most 24 inches of soil and with Gómez (1) results in Puerto Rico in which 51.39 percent of the total amount of roots excavated at a depth of from 0 to 48 inches, is found in the hilled-up and top-most 0–8 inch soil depth.

However, it is believed by the writers that the concentration of 94 percent of the total amount of roots excavated is a little abnormal and that must be due to an abnormal soil condition, in this case, the imperfect drainage typical of the Coloso Clay soil. From measurements taken on individual 2-year old trees in the coffee experimental fields planted at the Puerto Rico Experiment Station of the United States Department of Agriculture at Mayagüez which indicate the height, lateral spread and trunk diameter that may be attained by trees under proper soil and cultivation, and from observations made on individual trees at commercial fields, it is found when comparing the growth of trees used for this study with trees of less age, that the 6 trees studied had not developed properly.

The Coloso Clay Soil being regarded as a productive soil in Puerto Rico is not responsible for the growth attained by the trees in 7 years, but the improper drainage due to special environmental con-

ditions prevailing in the locality where the excavations were performed. It is expected that with better drainage conditions the growth attained by the six trees would had been greater and the penetration and lateral extension of the root system would had been greater also at the various soil depths studied.

Although Coloso Clay is not the most common type of soil found in the coffee region of Puerto Rico it is present at flat, level places, near streams in farms where the Catalina Clay is abundant. Therefore, it is recomemnded to provide the coffee plantations growing in localities of conditions similar to those prevailing at the place where these studies were conducted, with proper drainage so that the growth of the trees may be normal and the production of the field, greater.

The relatively high percent of organic matter of Coloso Clay accounts to some extent for the greater concentration of roots at the top-most 12 inches of soil although the effect of better aeration of surface layers is also responsible for a greater quantity of roots to be present in the first layer excavated. Nutman (5) found that manurial aplications always resulted in an increased feeder-growth in the neighborhood of the manure.

Apparently, the texture of the soil and the concentration of the principal plant foods do not affect the growth of roots. This applies especially to the results obtained by this study because with the exception of a few figures of the physical and chemical analyses of the 4 soil depths studied, the texture and the concentration of nutrients was quite uniform for the 4 layers in which roots were excavated.

Contrary to the common believe that an exhuberant vegetative condition of tree tops must be correlated with a heavy and extensive root system, the results obtained in this study indicate that the conditions of growth of tree tops cannot be considered in figuring the conditions of growth of the root system because a heavy top is not dependent on a strong and extensive root system, judging from the figures shown in tables V, VI and VIII. The results obtained are in accord with those obtained by Lee (2), (3) and Gómez (1) in their stuides of the root systems of sugar cane in Hawaii, the Philippine Islands and Puerto Rico.

According to the figures shown by table VII there is no fixed ratio of tops to roots in coffee no matter whether dry or green weights of tops and roots are used for determining the ratio. This accords with Weaver's (9), (10) results with studies of the root systems of plants in the United States. It may be stated conclusively that the ratio of tops to roots of young coffee trees was approximately 8:1.

In selecting trees with a vigorous and abundant vegetative condition at the tops and strong, extensive root systems, the diameter of the trunk is a better indication of the possession of these desirable characteristics than either the lateral spread or the height. This was shown definitely by the figures in tables VI and VIII already explained. In the six trees studied, those with a trunk diameter of 4 cms. or above were the trees with the heavier tops and heavier and more extensive root systems.

The new method of studying root systems of crop plants, developed by the writers and used for studying the root system of coffee, *C. arabica* L. in Puerto Rico, besides making it possible to obtain the information discussed already, enables us to propose a description for the root system of coffee based strictly on the results obtained. Such root system may be described to have the form of an inverted cone with a wide base; the spread of the roots in the top-most 12 inches of soil, and a rather small height, the vertical penetration. There is really no pivot or main root in the coffee root system. The broad, central root noticed in text figure No. 2, is part of the stem, buried as a result of a tendency of our farmers to plant the coffee seedlings too deep into the planting holes. At a very short distance from the collar of the stems (the collar is regarded as that point in between the stem and the root system) a number of roots are found spreading out laterally and vertically which have a greater diameter than any other roots in the system. These main or primary roots give rise to secondary and tertiary roots, each of smaller diameter, and largely on the tertiary roots the root hairs are originated. According to the results obtained and the observations made in the field, the tertiary roots with root hairs are present in great quantities in the top-most 12 inches of soil and they originate at any point or distance from the center of the root system. The tertiary roots with the root hairs may originate at any part of either the main or secondary roots. It must be explained that the terminology of main, secondary and tertiary is based on the diameter of the roots and not on a systematic branching, in other words, tertiaries with root hairs have been observed to occur even on the buried stem adjoining the root system.

From the description of the root system just proposed it may be concluded that the absorbing area of the root system of coffee is not confined to definite places on the soil, but is evenly distributed in all places penetrated by the main and secondary roots.

Application of the Results Obtained

Although the results obtained thus far need further confirmation, with the information gathered, it is possible to make some recommendations for the improvement of agricultural operations followed in the coffee plantations as follows:

(*a*) The greatest quantity of roots, 94 percent of the total roots excavated for the six trees, is found in the top-most 12 inches of soil.

(*b*) In the top-most 12 inches of soil, the roots of some of the trees extended laterally more than four feet.

(*c*) The maximum vertical penetration of the roots of most trees is three feet.

(*d*) The high content of the organic matter of the excavated at the top-most 12 inches and the better aeration of surface layers are apparently responsible for the greater quantities of roots found in the top-most 12 inches of soil.

In view of these facts, the young coffee tree is a surface feeder and shade trees or crop plants such as oranges and bananas should never be interplanted with coffee because of similar root-habits. In case, bananas are used to provide shade to the young coffee seedlings, the banana plants should be eliminated as soon as the permanent shade trees provide the coffee with the desired shade. Also, the excessive number of shade trees per cuerda, usually noticed in the plantations should be eliminated in order to reduce the competition for plant food to a minimum.

Coffee seedlings should always be planted at a minimum distance of 8 ft. $\times$ 8 ft. This is shown clearly in the first layers of the excavation maps (text figures 3 to 8) of most trees. The roots in the top-most 12 inches extended laterally 4 ft. or more showing that young trees in a relatively small number of years need and individual area of 64 sq. ft. for the development of the roots. When it is supposed that older trees will develop stronger and more extensive root systems it is realized that the minimum planting distance must be at 8 $\times$ 8 ft. Therefore, a cuerda of coffee should not have more than 625 coffee trees in order to provide an adequate land surface from which to withdraw an ample supply of plant foods.

The surface-feeding habit of coffee trees specially while young requires deep soils for a reasonable amount of growth and productivity. Many failures to grow coffee on shallow soils have been recorded.

Tree no. 1

First layer: 0"-12"

B-1 0	B-2 0	B-3 0	B-4 0.1999	B-5 0.1051	B-6 0.0907	B-7 0.0274	B-8 0.0119
B-9 0.0614	B-10 0.0550	B-11 0.1762	B-12 0.1680	B-13 0.4964	B-14 0.1790	B-15 0	B-16 0
B-17 0	B-18 0.5104	B-19 2.8452	B-20 3.1360	B-21 3.4534	B-22 1.3930	B-23 0.0708	B-24 0
B-25 0.0074	B-26 0.6196	B-27 3.2926	B-28 50.3452	B-29 58.1010	B-30 2.6846	B-31 0.4864	B-32 0
B-33 0	B-34 0.3112	B-35 0.9170	B-36 4.5854	•B-37 18.4422	B-38 1.1974	B-39 0.3558	B-40 0
B-41 0	B-42 0.2936	B-43 0.2964	B-44 0.3498	B-45 4.4640	B-46 1.8186	B-47 0.2798	B-48 0
B-49 0	B-50 0	B-51 0	B-52 0.1200	B-53 0.3690	B-54 0.5060	B-55 0	B-56 0.0342
B-57 0	B-58 0	B-59 0	B-60 0	B-61 0	B-62 0	B-63 0	B-64 0

Second layer: 12"-24"

B-1 0	B-2 0	B-3 0	B-4 0	B-5 0	B-6 0	B-7 0	B-8 0
B-9 0	B-10 0	B-11 0.3414	B-12 0.0206	B-13 0	B-14 0	B-15 0	B-16 0
B-17 0	B-18 0.0618	B-19 0.1598	B-20 0.4698	B-21 0.2472	B-22 0	B-23 0	B-24 0
B-25 0	B-26 0	B-27 0.0684	B-28 0.7162	B-29 0.4862	B-30 0	B-31 0	B-32 0
B-33 0	B-34 0	B-35 0	B-36 0.6818	•B-37 0.1612	B-38 0.0416	B-39 0.0197	B-40 0
B-41 0	B-42 0	B-43 0	B-44 0.0868	B-45 0.1680	B-46 0.4492	B-47 0.0532	B-48 0
B-49 0	B-50 0	B-51 0	B-52 0.1054	B-53 0	B-54 0.0384	B-55 0	B-56 0
B-57 0	B-58 0	B-59 0	B-60 0	B-61 0	B-62 0	B-63 0	B-64 0

Third layer: 24"-36"

B-1 0	B-2 0	B-3 0	B-4 0	B-5 0	B-6 0	B-7 0	B-8 0
B-9 0	B-10 0	B-11 0	B-12 0	B-13 0	B-14 0	B-15 0	B-16 0
B-17 0	B-18 0	B-19 0	B-20 0	B-21 0	B-22 0	B-23 0	B-24 0
B-25 0	B-26 0	B-27 0	B-28 0	B-29 0.0514	B-30 0.0208	B-31 0	B-32 0
B-33 0	B-34 0	B-35 0	B-36 0.0454	•B-37 0	B-38 0	B-39 0	B-40 0
B-41 0	B-42 0	B-43 0	B-44 0	B-45 0	B-46 0	B-47 0	B-48 0
B-49 0	B-50 0	B-51 0	B-52 0	B-53 0	B-54 0	B-55 0	B-56 0
B-57 0	B-58 0	B-59 0	B-60 0	B-61 0	B-62 0	B-63 0	B-64 0

Fourth layer: 36"-48"

B-1 0	B-2 0	B-3 0	B-4 0	B-5 0	B-6 0	B-7 0	B-8 0
B-9 0	B-10 0	B-11 0	B-12 0	B-13 0	B-14 0	B-15 0	B-16 0
B-17 0	B-18 0	B-19 0	B-20 0	B-21 0	B-22 0	B-23 0	B-24 0
B-25 0	B-26 0	B-27 0	B-28 0	B-29 0	B-30 0	B-31 0	B-32 0
B-33 0	B-34 0	B-35 0	B-36 0	B-37 0	B-38 0	B-39 0	B-40 0
B-41 0	B-42 0	B-43 0	B-44 0	B-45 0	B-46 0	B-47 0	B-48 0
B-49 0	B-50 0	B-51 0	B-52 0	B-53 0	B-54 0	B-55 0	B-56 0
B-57 0	B-58 0	B-59 0	B-60 0	B-61 0	B-62 0	B-63 0	B-64 0

G.G.

B-12 = block number; 0.0274 = dry weight in grams of roots in one cubic foot of soil; •= location of tree trunk; 0 = blocks without roots.

Diagram indicating dry weight of roots per cubic foot of soil excavated in each layer of tree 1.

Text figure no. 3

Tree no. 2

First layer: 0"-12"

B-65 O	B-66 O	B-67 1.2058	B-68 0.7715	B-69 0.0398	B-70 0.0782	B-71 0.0918	B-72 O
B-73 0.2554	B-74 0.0766	B-75 0.0704	B-76 0.3506	B-77 0.4992	B-78 0.1732	B-79 0.0030	B-80 0.0174
B-81 O	B-82 0.0920	B-83 0.4902	B-84 5.5076	B-85 2.8896	B-86 0.8294	B-87 0.0896	B-88 O
B-89 0.0034	B-90 0.3116	B-91 3.7120	B-92 17.5400	B-93 2.8812	B-94 1.9848	B-95 0.3132	B-96 O
B-97 O	B-98 O	B-99 1.4472	B-100 • 192.54	B-101 28.67	B-102 2.3648	B-103 O	B-104 O
B-105 O	B-106 O	B-107 2.0811	B-108 8.1050	B-109 5.3400	B-110 2.2678	B-111 0.1986	B-112 O
B-113 O	B-114 O	B-115 O	B-116 2.5502	B-117 1.7394	B-118 0.1434	B-119 O	B-120 O
B-121 O	B-122 O	B-123 O	B-124 0.4678	B-125 0.3518	B-126 O	B-127 O	B-128 O

Second layer: 12"-24"

B-65 O	B-66 O	B-67 O	B-68 O	B-69 O	B-70 O	B-71 O	B-72 O
B-73 O	B-74 O	B-75 O	B-76 0.1092	B-77 0.1034	B-78 O	B-79 O	B-80 O
B-81 O	B-82 O	B-83 O	B-84 0.6890	B-85 0.3878	B-86 0.0834	B-87 O	B-88 O
B-89 O	B-90 O	B-91 O	B-92 0.1385	B-93 1.1808	B-94 0.1122	B-95 O	B-96 O
B-97 O	B-98 O	B-99 0.0770	B-100 • 3.3460	B-101 1.1478	B-102 0.1680	B-103 O	B-104 O
B-105 O	B-106 O	B-107 0.1230	B-108 1.1730	B-109 0.8062	B-110 0.3991	B-111 0.4188	B-112 O
B-113 O	B-114 O	B-115 O	B-116 0.2008	B-117 0.0456	B-118 O	B-119 O	B-120 O
B-121 O	B-122 O	B-123 O	B-124 0.0792	B-125 O	B-126 O	B-127 O	B-128 O

Third layer: 24"-36"

B-65 O	B-66 O	B-67 O	B-68 O	B-69 O	B-70 O	B-71 O	B-72 O
B-73 O	B-74 O	B-75 O	B-76 O	B-77 O	B-78 O	B-79 O	B-80 O
B-81 O	B-82 O	B-83 0.1008	B-84 0.0400	B-85 O	B-86 O	B-87 O	B-88 O
B-89 O	B-90 O	B-91 O	B-92 O	B-93 O	B-94 O	B-95 O	B-96 O
B-97 O	B-98 O	B-99 O	B-100 • 0.6730	B-101 0.1980	B-102 O	B-103 O	B-104 O
B-105 O	B-106 O	B-107 O	B-108 O	B-109 0.0254	B-110 O	B-111 O	B-112 O
B-113 O	B-114 O	B-115 O	B-116 O	B-117 O	B-118 O	B-119 O	B-120 O
B-121 O	B-122 O	B-123 O	B-124 O	B-125 O	B-126 O	B-127 O	B-128 O

Fourth layer: 36"-48"

B-65 O	B-66 O	B-67 O	B-68 O	B-69 O	B-70 O	B-71 O	B-72 O
B-73 O	B-74 O	B-75 O	B-76 O	B-77 O	B-78 O	B-79 O	B-80 O
B-81 O	B-82 O	B-83 O	B-84 O	B-85 O	B-86 O	B-87 O	B-88 O
B-89 O	B-90 O	B-91 O	B-92 O	B-93 O	B-94 O	B-95 O	B-96 O
B-97 O	B-98 O	B-99 O	B-100 O	B-101 O	B-102 O	B-103 O	B-104 O
B-105 O	B-106 O	B-107 O	B-108 O	B-109 O	B-110 O	B-111 O	B-112 O
B-113 O	B-114 O	B-115 O	B-116 O	B-117 O	B-118 O	B-119 O	B-120 O
B-121 O	B-122 O	B-123 O	B-124 O	B-125 O	B-126 O	B-127 O	B-128 O

B-67 = block number; 1.2058 = dry weight in grams of roots in one cubic foot of soil;
• = location of tree trunk; O = blocks without roots.

Diagram indicating dry weight of roots per cubic foot of soil excavated in each layer of tree 2.

Text figure no. 4

Tree no 3

First layer: 0"-12"

B-129	B-130	B-131	B-132	B-133	B-134	B-135	B-136
0	0	0	0.5932	0.5557	0.0404	0.0518	0.4178
B-137	B-138	B-139	B-140	B-141	B-142	B-143	B-144
0.0027	0	0.0290	0.2948	0.1880	0.2777	0.2120	0.0092
B-145	B-146	B-147	B-148	B-149	B-150	B-151	B-152
0.0268	0.0077	0	0.3308	1.5154	2.9248	0.1297	0.1114
B-153	B-154	B-155	B-156	B-157	B-158	B-159	B-160
0.0710	0.8104	1.7728	1.2538	8.4284	7.4792	0.8512	0.0766
B-161	B-162	B-163	B-164	B-165	B-166	B-167	B-168
0	0	2.1461	106.52	4.8424	27.2988	0	0.0898
B-169	B-170	B-171	B-172	B-173	B-174	B-175	B-176
0.3542	0.1826	2.4066	9.1652	10.8420	3.4560	0.4246	0
B-177	B-178	B-179	B-180	B-181	B-182	B-183	B-184
0	0	0.4764	0.6348	1.4670	0.4746	0.2610	0
B-185	B-186	B-187	B-188	B-189	B-190	B-191	B-192
0	0	0	0.2461	0.1888	0.0156	0	0

Second layer: 12"-24"

B-129	B-130	B-131	B-132	B-133	B-134	B-135	B-136
0	0	0	0	0	0	0	0
B-137	B-138	B-139	B-140	B-141	B-142	B-143	B-144
0	0	0	0.1488	0.6322	0	0	0
B-145	B-146	B-147	B-148	B-149	B-150	B-151	B-152
0	0	0	0	0.2440	0.1214	0	0
B-153	B-154	B-155	B-156	B-157	B-158	B-159	B-160
0	0	0.2544	0.2934	0.2792	0	0	0
B-161	B-162	B-163	B-164	B-165	B-166	B-167	B-168
0	0.1138	0.8323	1.8114	2.2794	0.8820	0	0
B-169	B-170	B-171	B-172	B-173	B-174	B-175	B-176
0	0.2770	0.1824	1.4356	0.4230	0.5888	0.0706	0
B-177	B-178	B-179	B-180	B-181	B-182	B-183	B-184
0	0	0	0.4804	0	0	0	0
B-185	B-186	B-187	B-188	B-189	B-190	B-191	B-192
0	0	0	0	0	0	0	0

Third layer: 24"-36"

B-129	B-130	B-131	B-132	B-133	B-134	B-135	B-136
0	0	0	0	0	0	0	0
B-137	B-138	B-139	B-140	B-141	B-142	B-143	B-144
0	0	0	0	0	0	0	0
B-145	B-146	B-147	B-148	B-149	B-150	B-151	B-152
0	0	0	0	0	0	0	0
B-153	B-154	B-155	B-156	B-157	B-158	B-159	B-160
0	0	0	0	0	0	0	0
B-161	B-162	B-163	B-164	B-165	B-166	B-167	B-168
0	0	0	0.0985	0.0320	0	0	0
B-169	B-170	B-171	B-172	B-173	B-174	B-175	B-176
0	0	0.0474	0.0858	0	0	0	0
B-177	B-178	B-179	B-180	B-181	B-182	B-183	B-184
0	0	0	0	0	0	0	0
B-185	B-186	B-187	B-188	B-189	B-190	B-191	B-192
0	0	0	0	0	0	0	0

Fourth layer: 36"-48"

B-129	B-130	B-131	B-132	B-133	B-134	B-135	B-136
0	0	0	0	0	0	0	0
B-137	B-138	B-139	B-140	B-141	B-142	B-143	B-144
0	0	0	0	0	0	0	0
B-145	B-146	B-147	B-148	B-149	B-150	B-151	B-152
0	0	0	0	0	0	0	0
B-153	B-154	B-155	B-156	B-157	B-158	B-159	B-160
0	0	0	0	0	0	0	0
B-161	B-162	B-163	B-164	B-165	B-166	B-167	B-168
0	0	0	0	0.1208	0.3075	0	0
B-169	B-170	B-171	B-172	B-173	B-174	B-175	B-176
0.2238	0	0	0	0	0	0	0
B-177	B-178	B-179	B-180	B-181	B-182	B-183	B-184
0	0	0	0	0	0	0	0
B-185	B-186	B-187	B-188	B-189	B-190	B-191	B-192
0	0	0	0	0	0	0	0

B-132 = block number; 0.5932 = dry weight in grams of roots in one cubic foot of soil;
● = location of tree trunk; 0 = blocks without roots

Diagram indicating dry weight of roots per cubic foot of soil excavated in each layer of tree 3.

Text figure no. 5

Tree no. 4

First layer: 0"-12"

B-193	B-194	B-195	B-196	B-197	B-198	B-199	B-200
0	0	0	0.0023	0	0	0	0
B-201	B-202	B-203	B-204	B-205	B-206	B-207	B-208
0.0194	0.0192	0	0	0	0	0	0
B-209	B-210	B-211	B-212	B-213	B-214	B-215	B-216
0	0	1.0567	0.0442	0.0400	0	0	0
B-217	B-218	B-219	B-220	B-221	B-222	B-223	B-224
0	0.3898	2.0376	0.1924	0.2098	0.4158	0	0
B-225	B-226	B-227	B-228	B-229	B-230	B-231	B-232
0	0.0624	4.0936	72.1930	2.6394	0.5094	0	0
B-233	B-234	B-235	B-236	B-237	B-238	B-239	B-240
0	0.2442	18.5546	2.6894	3.1380	0.8170	0.0158	0
B-241	B-242	B-243	B-244	B-245	B-246	B-247	B-248
0	0.2250	0.0240	0.6428	2.1268	0.1830	0	0
B-249	B-250	B-251	B-252	B-253	B-254	B-255	B-256
0	0	0	0.0670	0.4037	0.9352	0.2280	

Second layer: 12"-24"

B-193	B-194	B-195	B-196	B-197	B-198	B-199	B-200
0	0	0	0	0	0	0	0
B-201	B-202	B-203	B-204	B-205	B-206	B-207	B-208
0	0	0	0	0	0	0	0
B-209	B-210	B-211	B-212	B-213	B-214	B-215	B-216
0	0	0	0	0	0	0	0
B-217	B-218	B-219	B-220	B-221	B-222	B-223	B-224
0	0	0.1148	0.0560	0.0537	0	0	0
B-225	B-226	B-227	B-228	B-229	B-230	B-231	B-232
0	0	0.0192	3.7660	0	0.3192	0	0
B-233	B-234	B-235	B-236	B-237	B-238	B-239	B-240
0	0	0.0464	0.3108	0.3282	0.1810	0.0346	0
B-241	B-242	B-243	B-244	B-245	B-246	B-247	B-248
0	0	0	0	0.3236	0	0	0
B-249	B-250	B-251	B-252	B-253	B-254	B-255	B-256
0	0	0	0	0	0	0	0

Third layer: 24"-36"

B-193	B-194	B-195	B-196	B-197	B-198	B-199	B-200
0	0	0	0	0	0	0	0
B-201	B-202	B-203	B-204	B-205	B-206	B-207	B-208
0	0	0	0	0	0	0	0
B-209	B-210	B-211	B-212	B-213	B-214	B-215	B-216
0	0	0	0	0	0.4208	0	0
B-217	B-218	B-219	B-220	B-221	B-222	B-223	B-224
0	0	0	0	0	0	0	0
B-225	B-226	B-227	B-228	B-229	B-230	B-231	B-232
0	0	0.0700	0.2616	0	0	0	0
B-233	B-234	B-235	B-236	B-237	B-238	B-239	B-240
0	0	0.0574	0.1184	0.0110	0.0230	0	0
B-241	B-242	B-243	B-244	B-245	B-246	B-247	B-248
0	0	0	0	0	0	0	0
B-249	B-250	B-251	B-252	B-253	B-254	B-255	B-256
0	0	0	0	0	0	0	0

Fourth layer: 36"-48"

B-193	B-194	B-195	B-196	B-197	B-198	B-199	B-200
0	0	0	0	0	0	0	0
B-201	B-202	B-203	B-204	B-205	B-206	B-207	B-208
0	0	0	0	0	0	0	0
B-209	B-210	B-211	B-212	B-213	B-214	B-215	B-216
0	0	0	0	0	0	0	0
B-217	B-218	B-219	B-220	B-221	B-222	B-223	B-224
0	0	0	0	0	0	0	0
B-225	B-226	B-227	B-228	B-229	B-230	B-231	B-232
0	0	0	0	0	0	0	0
B-233	B-234	B-235	B-236	B-237	B-238	B-239	B-240
0	0	0	0	0	0	0	0
B-241	B-242	B-243	B-244	B-245	B-246	B-247	B-248
0	0	0	0	0	0	0	0
B-249	B-250	B-251	B-252	B-253	B-254	B-255	B-256
0	0	0	0	0	0	0	0

B-196 = block number; 0.0023 = dry weight in grams of roots in one cubic foot of soil;
• = location of tree trunk; 0 = blocks without roots

Diagram indicating dry weight of roots per cubic foot of soil excavated in each layer of tree 4.

Text figure no. 6

Tree no.5

First layer: 0"-12"

B-257 O	B-258 O	B-259 0.0444	B-260 0.0148	B-261 O	B-262 0.0138	B-263 0.0094	B-264 0.0064
B-265 0.0296	B-266 0.0238	B-267 0.0447	B-268 O	B-269 0.0036	B-270 0.0464	B-271 0.0294	B-272 O
B-273 0.1732	B-274 0.1060	B-275 O	B-276 0.0792	B-277 0.7319	B-278 O	B-279 O	B-280 O
B-281 O	B-282 0.3820	B-283 0.8950	B-284 0.5699	B-285 0.4776	B-286 2.4616	B-287 0.9084	B-288 O
B-289 0.7936	B-290 0.9804	B-291 2.0512	B-292 7.9846	B-293 4.1830	B-294 4.6524	B-295 0.6710	B-296 O
B-297 1.0338	B-298 1.8522	B-299 8.4340	B-300 73.9154	B-301 29.2416	B-302 3.2820	B-303 O	B-304 O
B-305 1.6272	B-306 2.4431	B-307 0.9932	B-308 5.4614	B-309 8.0790	B-310 2.9224	B-311 0.1464	B-312 0.4854
B-313 O	B-314 1.1518	B-315 0.6670	B-316 0.2566	B-317 3.4512	B-318 4.0612	B-319 1.6464	B-320 0.3170

Second layer: 12"-24"

B-257 O	B-258 O	B-259 O	B-260 O	B-261 O	B-262 O	B-263 O	B-264 O
B-265 O	B-266 O	B-267 O	B-268 O	B-269 O	B-270 O	B-271 O	B-272 O
B-273 O	B-274 O	B-275 O	B-276 O	B-277 O	B-278 0.1168	B-279 O	B-280 O
B-281 O	B-282 O	B-283 O	B-284 0.0728	B-285 0.5146	B-286 0.0192	B-267 0.0801	B-288 0.1032
B-289 O	B-290 O	B-291 0.9250	B-292 2.5664	B-293 0.8100	B-294 0.2902	B-295 O	B-296 O
B-297 O	B-298 O	B-299 0.3488	B-300 5.3712	B-301 1.5020	B-302 O	B-303 0.3116	B-304 O
B-305 O	B-306 O	B-307 0.1104	B-308 0.7844	B-309 0.8648	B-310 0.4148	B-311 0.0761	B-312 O
B-313 O	B-314 O	B-315 O	B-316 O	B-317 0.1438	B-318 0.3762	B-319 0.2124	B-320 O

Third layer: 24"-36"

B-257 O	B-258 O	B-259 O	B-260 O	B-261 O	B-262 O	B-263 O	B-264 O
B-265 O	B-266 O	B-267 O	B-268 O	B-269 O	B-270 O	B-271 O	B-272 O
B-273 O	B-274 O	B-275 O	B-276 O	B-277 O	B-278 O	B-279 O	B-280 O
B-281 O	B-282 O	B-283 O	B-284 O	B-285 O	B-286 O	B-287 O	B-288 O
B-289 O	B-290 O	B-291 O	B-292 0.0500	B-293 0.2954	B-294 O	B-295 O	B-296 O
B-297 O	B-298 O	B-299 0.1242	B-300 0.1462	B-301 0.3220	B-302 O	B-303 O	B-304 O
B-305 O	B-306 O	B-307 O	B-308 O	B-309 O	B-310 O	B-311 O	B-312 O
B-313 O	B-314 O	B-315 O	B-316 O	B-317 O	B-318 O	B-319 O	B-320 O

Fourth layer: 36"-48"

B-257 O	B-258 O	B-259 O	B-260 O	B-261 O	B-262 O	B-263 O	B-264 O
B-265 O	B-266 O	B-267 O	B-268 O	B-269 O	B-270 O	B-271 O	B-272 O
B-273 O	B-274 O	B-275 O	B-276 O	B-277 O	B-278 O	B-279 O	B-280 O
B-281 O	B-282 O	B-283 O	B-284 O	B-285 O	B-286 O	B-287 O	B-288 O
B-289 O	B-290 O	B-291 O	B-292 O	B-293 O	B-294 O	B-295 O	B-296 O
B-297 O	B-298 O	B-299 O	B-300 O	B-301 O	B-302 O	B-303 O	B-304 O
B-305 O	B-306 O	B-307 O	B-308 O	B-309 O	B-310 O	B-311 O	B-312 O
B-313 O	B-314 O	B-315 O	B-316 O	B-317 O	B-318 O	B-319 O	B-320 O

B-259 = block number; 0.0444 = dry weight in grams of roots in one cubic foot of soil;
● = location of tree trunk; O = blocks without roots

Diagram indicating dry weight of roots per cubic foot of soil excavated in each layer of tree 5

Text figure no. 7

Tree no. 6

First layer: 0"-12"

B-321	B-322	B-323	B-324	B-325	B-326	B-327	B-328
O	O	0.0098	0.0078	0.6494	0.1392	0.0160	0.0315
B-329	B-330	B-331	B-332	B-333	B-334	B-335	B-336
O	O	O	O	O	0.8162	0.0082	O
B-337	B-338	B-339	B-340	B-341	B-342	B-343	B-344
O	O	O	O	O	O	O	O
B-345	B-346	B-347	B-348	B-349	B-350	B-351	B-352
O	O	O	0.3830	1.2182	0.3182	O	O
B-353	B-354	B-355	B-356	B-357	B-358	B-359	B-360
0.1656	1.2126	0.3616	8.7864	3.2454	0.4760	0.7996	O
B-361	B-362	B-363	B-364	B-365	B-366	B-367	B-368
0.0706	2.5303	3.6772	82.53	84.90	6.4214	1.5778	O
B-369	B-370	B-371	B-372	B-373	B-374	B-375	B-376
O	O	1.3386	9.3220	9.4506	5.3974	0.1358	O
B-377	B-378	B-379	B-380	B-381	B-382	B-383	B-384
0.1944	O	O	2.5728	0.1028	0.8676	O	O

Second layer: 12"-24"

B-321	B-322	B-323	B-324	B-325	B-326	B-327	B-328
O	O	O	O	O	O	O	O
B-329	B-330	B-331	B-332	B-333	B-334	B-335	B-336
O	O	O	O	O	O	O	O
B-337	B-338	B-339	B-340	B-341	B-342	B-343	B-344
O	O	O	O	O	O	O	O
B-345	B-346	B-347	B-348	B-349	B-350	B-351	B-352
O	O	O	O	O	O	O	O
B-353	B-354	B-355	B-356	B-357	B-358	B-359	B-360
0.2392	O	O	0.1804	0.5814	0.1126	O	O
B-361	B-362	B-363	B-364	B-365	B-366	B-367	B-368
O	O	1.0916	3.5684	5.7730	0.1908	O	O
B-369	B-370	B-371	B-372	B-373	B-374	B-375	B-376
O	O	O	1.0802	2.2860	0.0836	O	O
B-377	B-378	B-379	B-380	B-381	B-382	B-383	B-384
O	O	O	O	O	O	O	O

Third layer: 24"-36"

B-321	B-322	B-323	B-324	B-325	B-326	B-327	B-328
O	O	O	O	O	O	O	O
B-329	B-330	B-331	B-332	B-333	B-334	B-335	B-336
O	O	O	O	O	O	O	O
B-337	B-338	B-339	B-340	B-341	B-342	B-343	B-344
O	O	O	O	O	O	O	O
B-345	B-346	B-347	B-348	B-349	B-350	B-351	B-352
O	O	O	O	O	O	O	O
B-353	B-354	B-355	B-356	B-357	B-358	B-359	B-360
O	O	O	0.1078	0.1207	0.1408	O	O
B-361	B-362	B-363	B-364	B-365	B-366	B-367	B-368
O	O	0.0262	1.3864	1.3996	0.2040	O	O
B-369	B-370	B-371	B-372	B-373	B-374	B-375	B-376
O	O	0.5400	1.1872	0.2168	O	O	O
B-377	B-378	B-379	B-380	B-381	B-382	B-383	B-384
O	O	O	O	0.0754	O	O	O

Fourth layer: 36"-48"

B-321	B-322	B-323	B-324	B-325	B-326	B-327	B-328
O	O	O	O	O	O	O	O
B-329	B-330	B-331	B-332	B-333	B-334	B-335	B-336
O	O	O	O	O	O	O	O
B-337	B-338	B-339	B-340	B-341	B-342	B-343	B-344
O	O	O	O	O	O	O	O
B-345	B-346	B-347	B-348	B-349	B-350	B-351	B-352
O	O	O	O	O	O	O	O
B-353	B-354	B-355	B-356	B-357	B-358	B-359	B-360
O	O	O	O	O	O	O	O
B-361	B-362	B-363	B-364	B-365	B-366	B-367	B-368
O	O	O	O	0.0154	O	O	O
B-369	B-370	B-371	B-372	B-373	B-374	B-375	B-376
O	O	O	O	O	O	O	O
B-377	B-378	B-379	B-380	B-381	B-382	B-383	B-384
O	O	O	O	O	O	O	O

B-323 = block number; 0.0098 = dry weight in grams of roots in one cubic foot of soil;
● = location of tree trunk; O = blocks without roots.

Diagram indicating dry weight of roots per cubic foot of soil excavated in each layer of tree 6.

Text figure no. 8

As to planting system, the coffee seedlings should never be buried in the planting holes at time of planting. There is a tendency in the farmers to plant too deep which results in the tender new roots have to penetrate in hard, less fertile layers of soil affecting tremendously the rate and total amount of growth of the whole tree. The seedlings should be planted at the same level as that of the plants in the nursery, in this way all the good soil characteristics of the surface layers give the young seedlings better chances for a strong, vigorous development.

However, the root systems should be gradually induced to penetrate to deeper soil depths so that the roots may resist prolonged droughts, and absorb nutrients when the surface layers begin to get short of water and plant foods. This may be accomplished by making deep holes half way between the rows of trees in which to apply vegetable manures and chemical fertilizers. Such holes would in addition serve as deposits for fallen leaves and other plant débris.

In performing general agricultural operations, care should be taken to prune and mutilate the least number of roots by using proper tools and not operating too close to the tree trunks. This is possible by cultivating only in narrow strips half-way between the rows of trees. Recently vertical forks have been used successfully by numerous farmers because of their adaptability to loosen the soil breaking the least number of roots.

The coffee seedlings is susceptible to stagnant water, therefore, in soils with imperfect drainage, drainage ditchs should be provided in order to dispose of the excessive moisture.

The greatest concentration of roots being found at the top-most soil layer, fertilizer applications need not to be applied too deep. It is recommended to loosen the soil slightly under the drip of the trees and mix the fertilizer applied with the top soil and mulch. But on steep soils the fertilizer must be applied on the individual terraces or in shallow pits dug-out at the trunks in order to avoid washing of the fertilizer during heavy rainfall.

The better aeration of the surface layer is responsible to a certain extent for the greatest concentration of roots at the top-most 12 inches, therefore the soil of coffee plantations should be loosened to improve the aeration and consequently promote all the physical, chemical and biologic processes necssary for optimum root growth.

SUMMARY

1. The various methods used by Gómez (1) Lee (2) Lee and Bissinger (3), Nutman (4), (5), (6), Trench (7), Venkatraman (8), and Weaver and his associated (9), (10) for the study of the root system of plants have been described and discussed fully.

2. A new method developed by the writers has been described and used for the study of the root system of coffee, *C. arabica* L. in Puerto Rico. Briefly, this method consists in excavating the volume of soil assigned to each tree under study by blocks of one-cubic foot each and separating, drying and weighing the roots obtained from each block. By keeping an excavation map for the root system of the trees, the exact position of roots obtained for each block is obtained, therefore being possible to determine the quantity of roots present at the various soil levels excavated and the lateral spread of the roots as well.

3. Ninety-four percent of the coffee roots of all trees were found in the top-most 12 inches of soil.

4. The high percentage of organic matter in Coloso Clay, especially in the top-most layers, and the better aeration at the surface, apparently accounted to a great extent for the presence of more roots in the top-most 12 inches of soil.

5. The imperfect drainage conditions existing at localities where Coloso Clay predominates affect the development of the root systems of coffee plants.

6. Coloso Clay is a productive soil when proper drainage conditions are provided and the principal plant foods are generally distributed uniformly to a depth of 48 inches.

7. A heavy and vigorous coffee tree top is not dependent on an extensive root system.

8. There is no fixed "(tops to roots) ratio" in coffee trees, but generally the ratio of tops to roots may be figured to be 8:1.

9. In selecting trees with vigorous, heavy tops and a strong, extensive root systems, the diameter of the trunk is a better indication of the possession of these characteristics than either the height or the lateral spread of the tree.

10. There was approximately 50 percent of water in the upright stems of coffee trees, 23 percent in the lateral branches and leaves, 39 percent in the whole tree tops and 50 percent in the roots.

11. The absorbing area of the root system is not confined to definite places on the soil but is distributed thru-out all places penetrated by the main and secondary roots.

12. The vertical penetration of roots of 7-year-old trees is 3 feet and the lateral extension is 4 feet.

13. The results obtained have been discussed fully in relation to possible aplications in the performance of agricultural practices followed by farmers in coffee plantations.

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THIRD SUPPLEMENT
TO
PARTIAL BIBLIOGRAPHY OF VIRUS DISEASES OF PLANTS *

By JOSÉ I. OTERO, *Librarian* and MELVILLE T. COOK, *Pathologist.*

Abbot, E[rnest] V[ictor]
Conditions influencing germination of seed cane and stands with disease resistant varieties. Sugar Bull. **14**(20) : 1–6, 1936.
This paper contains brief references to mosaic but gives much more attention to other diseases.

Abegg, F. A., & Owen, F. V.
A genetic factor for curly-top disease resistance in beets (*Beta vulgaris* L.) and linkage relationships. Amer. Nat. (Abstract) **70**(726) : 36, 1936.

Acqua, C.
Sulla natura degli ultravirus. (On the nature of ultraviruses.) Rend. Sed. Reale Acad. Naz. Lincei **21** : 593–599, 1935.

Adams, J[ames] F[owler]
The curly top virus on spinach. Canning Trade **59**(10) : 7–8, 1936.
Popular.

Adams, R. L.
The California beet blight. Thesis for the M. S. degree. Univ. California 1909.

Afzal, Husain M.
Symposium on virus diseases of plants. Proc. Indian Sci. Congr. **20** : 445–454, 1933.

Ainsworth, G. C.
Spotted wilt of tomatoes. Expt. & Res. Sta. Cheshunt 18th Ann. Rpt. **1932** : 29–45, 1933.

Virus diseases. Expt. & Res. Sta. Cheshunt, 20th. Ann. Rpt. **1934** : 60–66, 1935.

(*) Journ. Agric. Univ. Puerto Rico 18(1–2) : 1–410, 1934; 19(2) : 129–313, 1935; 20(3) : 741–818, 1936.

Virus diseases. Expt. & Res. Sta. Cheshunt, 21st. Ann. Rpt. **1935**: 56–62, 1936.

Record of bushy stunt and fern leaf of tomatoes, fig mosaic, a mosaic of water cress, recovery from spotted wilt and effects of tobacco mosaic on seedlings of tomato plants.

Virus diseases. Expt. & Res. Sta. Cheshunt, 22nd. Ann. Rpt. **1936**: 59–62, 1937.

Record of Several diseases.

"Enation mosaic" of tomato caused by a virus of tobacco I type. Ann. Appl. Biol. **24**(3): 545–556, 1937.

This disease causes pronounced malformations of the leaves especially outgrowths on the under sides. This is caused by a strain of tobacco virus I.

Akenhead, D., Harris, R., Berkeley, G[arven] H[ugh] & Massee, A. M.

The degeneration of the strawberry. Imp. Bur. Fruit. Prod. East Malling, Tech. Comm. **5**, 28 p., 1934.

Probably crinkle or yellow edge.

Aleksandrov, A. G., & Aleksandrova, O. G.

(On the mosaic disease of wheat endosperm.) Compt. Rend. (Doklady) Acad. Sci. U.S.S.R. **17**(9): 495–498, 1937.

Allen, J.

Control of pests and diseases. Gard. Chron. **99**: 390, 1936.

Contains notes on "Big bud" on black currants.

Ando R.

(On dwarf disease of rice plant.) Journ. Japanese Agric. Soc. **347**: 1–3, 1910.

Andrews, F. W.

The effect of leaf curl disease on the yield of the cotton plant. Empire Cotton Grow. Rev. **13**(4): 287–298, 1936.

The disease is the cause of significant losses.

Anonymous

Experiments for the control of dwarf disease of potatoes. Oklahoma Agric. Expt. Sta. Ann. Rpt. **1915**: 143–144, 1916; **1916**: 183–184, 1917.

Varietal susceptibility of the potato to the curly dwarf. Oklahoma Agric. Expt. Sta. Ann. Rpt. **1915**: 20, 1916; **1916**: 20, 1917; **1919**: 65–66, 1921.

Effect of selection of "seeds" on the yield of the potato crop. Journ. Dept. Agric. Ireland **22**:378–380. 1923.

Popular notes on leaf roll diseases.

Bunchy-Top.—Departamental Action. Queensland Agric. Journ. **26**: 297–298, 1926.

Scotland: Plant diseases and pests. Intern. Rev. Agric. **22**(6): 94–95, 1931.

Contains a note on a virus disease of Aurantium lilies.

Investigations on the spike-disease of sandal I, IV, Bangalore, 1931–32. Indian Inst. Sci. Bangalore, 1932.

Contribution á la connaissance de la maladie del' enroulement des feuilles de la pomme de terre. (Contribution to the knowledge of the leaf roll disease of the potato.) Prog. Agric. & Vitic. (Montpellier) **100**: 507–509, 1933.

Insect transmission of spike-disease. Nature **132**(3337): 592–593, 1933.

Spotted wilt of tomatoes. Expt. & Res. Stat. Cheshunt, Circ. 7, 3 p., 1933.

The "degeneration" of the strawberry. Imp. Bur. Fruit Prod. Tech. Comm. **5**: 28, 1934.

The "kromnek" disease of tobacco. Rhodesia Agric. Journ. **3** (1): 9–10, 1934.

Poor potato stands traced to yellow dwarf. Wisconsin Agric. Expt. Sta. Ann. Rpt. **1932–1933**: 84–85, (Bull. **428**), 1934.

Recent research on Empire products. A record of work conducted by Government Technical Department overseas. Agriculture. Bull. Imp. Inst. **32**(3): 437–467, 1934.

Discusses cassava mosaic.

Summary report of progress, 1934. Maine Agric. Expt. Sta. Bull. **377**: 323–326, 1934.

Reports transmission studies of latent mosaic, mild leaf rolling, rugose mosaic and streak on potatoes.

Virus disease research. Scott. Soc. Res. Plant Breeding (Edinburg) Report **1933–34**: 15–17, 1934.

False blossom. U.S.D.A. Plant Disease Rept. **19**(8):121–128, 1935.

Mosaikkrankheiten in Perú. (Mosaic diseases in Perú.) Zeitschr. Zuckerind. Cechosl. Rpt. **60**: 204–205, 1935.

Mosaksyge hos agurke. Gartn. Tid. **51**(33): 417–419, 1935.

Virus apparently made visible at last. The Literary Digest July 13, p. 18, 1935.

Apparently popular.

Die Abbaukrankheiten der Kartoffel. Wiener Landw. Zeitg. **86**: 135, 1936.

Big bud currant reversion and the B.B.C. Gard. Chron. **99** (2577): 305, 1936.

Burgonya sárgafoltossága. Mezögazdaság **13**: 189, 1936.

The Columbian purple raspberry carries the virus causing mosaic in red and black raspberries. Farm. Res. New York State Stat. 2, No. 4, 12 p., 1936.

Filtrierbares Virus als Kranheitserreger bei Mensch, Tier und Pflanze. Ernährg. d. Pflanze **32**: 420–422, 1936.

High temperature favors yellow dwarf. Wisconsin Agric. Expt. Sta. Ann. Rpt. **1934–1935**: 103–105, 1936.

Learn manner in which tobacco mosaic overwinters in the soil. Wisconsin Agric. Expt. Sta. Ann. Rpt. **1934–1935**: 133, 1936.

Occurrence of English mosaic on red raspberry in Oregon. U.S.D.A. Plant Disease Rept. **20**(7): 123–125, 1936.

Phony peach disease under control. U.S.D.A. Plant Disease Rept. **20**(8): 138, 1936.

Peach virus diseases in Michigan in 1935. U.S.D.A. Plant Disease Rept. **20**(9): 145–146, 1936.

Phony peach disease found in Indiana and Pennsylvania. U.S.D.A. Plant Disease Rept. **20**: 296, 1936.

Potato Leaf-roll. Min. Agric. & Fisheries, London Adv. Leaflet **278**, 4 p., 1936.

La rosette de l'arachide. (Peanut rosette) Sta. Expt. de L'arachide Bombey. Bull. des Matiéres Grasses Inst. Col. Marseille **20**(8) : 201–205, 1936.

Virus diseases of peach. Michigan Agric. Expt. Sta. Bienn. Rpt. **1934–1936**: 21, 1936.

Virus diseases. Gard. Chron. **99**: 209, 353, 300, 1936.

Virus diseases of sugar cane. Int. Sugar Journ. **38**(453) : 330–332, 1936.

Streak disease in South Africa. Mr. Wuthrich's observations from India. South Africa Sugar Journ. **20**(8): 503–505, 1936.

Notes from a letter from Mr. E. G. Wuthrich.

New sugar-beet varieties for the curly-top area. U.S.D.A. Circ. **391**, 4 p., 1936.

Origen y desenvolvimiento del mosaico de la caña de azúcar. (Origen and development of sugar cane mosaic.) Rev. Agric. Puerto Rico **28**(4) : 749-763, 1937.

Review of conference by C. E. Chardon at the Sociedad de Agricultores de Colombia on January 22, 1937. Dr. Chardon made a review of the study of sugar cane mosaic with special reference to the work done in Puerto Rico.

Potato virus disease control. Agric. Gaz. New South Wales **48** (10) : 573–677, 1937.

Plant diseases recorded in New South Wales. Dept. Agric. New South Wales, Suppl. No. 7, 1937.

Records virus diseases on 27 hosts, some of them new.

Report Proc. Second Int. Congr. Microbiol. Contr. **1936**: 71–91, 1937.

Viruses and virus diseases in animals and plants. Discussion on the general characteristics of viruses, including bacteriophage. R. P. White, J. Henderson Smith, W. M. Stanley, K. M. Smith, F. C. Bawden, R. N. Salaman, H. H. Storey, and T. Matsumoto discussed on plant viruses.

Recovery from virus diseases causes immunity in tobacco. Journ. Tenn. Acad. Sci. **12**(2) : 178, 1937.

Dr. James Johnson has announced that tobacco plants recovering from tobacco streak acquire a considerable degree of immunity from further infections.

Ziekten en Beschadigingen van het aardappeloof. Virusziekten, Verslagen en Meded. van den Plantenziekten-kundigen Dienst te Wageningen. **6**, 31 p., 1937.

Contains a brief discussion of leaf-roll (phloemnecrosis, leptonecrosis) mosaic, crinkle in aucuba and stipplestreak.

Anson, R. R.
Leaf curl disease of cotton in the Fiji islands. Second Conf. Cotton Growing Problems, London, Rpt. **1934**: 195–196, 1934.

A record.

Antal, Gulyás
A magyar dohányok virusbetegségei. (Virus disease on Hungarian tobacco.) Különleyomat a Kiser Koz. **39**(1–3): 1–35, 1936.

The author states that the object of the paper is to study the biology of virus diseases of tobacco. He gives the behavior and symptoms of several tobacco virus diseases and their relative damage to the crop. Concludes by giving advise as to tobacco fertilization.

A burgonya virusbetegégei. (The virus diseases of the potato.) Különlenyomat a M. Kir. Gazdssagi Akadémia I. Kötet **3** füzetebol 63 p., 1938.

A study of the virus diseases of the potato that occur in Hungary.

Arnaud, G[abriel,] & Arnaud, M.
Les maladies a virus des Rosacées amygdalées. (The virus diseases of Amygdalaceous Rosaceae.) Compt. Rend. Acad. Sci. (Paris) **202**(10): 869–871, 1936.

A study of virus diseases of *Prunus persicae, P. spinosa* and *P. avium.*

Les maladies a virus des plantes. (Virus diseases of plants.) Prog. Agric. & Vitic. **106**(50): 562–567, 1936; **107**(2): 35–38, (4): 86–90, (5): 110–113, (6): 138–141, 1937.

The author discusses in semipopular form virus diseases of plants in general and some virus diseases in particular.

Artem'ev, G. V.
Virusnye Zabolevaniia rasteniia vo vlazhbykh subtropikakh. (Virus diseases of plants in humid subtropics.) Sovetsk. Subtrop. (Moskva) **1936**(12): 10–19, 1936.

Artschwager, Ernst, & Starrett, Ruth C[olvin]
Histological and cytological changes in sugar-beet seedlings effected with curly top. Journ. Agric. Res. **53**(9): 637–657, 1936.

A very complete study of the histology and cytology of the diseased plants.

Arthur, J[oseph] C[harles], & Golden, K. E.
Diseases of sugar beet root. Indiana Agric. Expt. Sta. Bull. **39**: 54–62, 1892.

The disease referred to in this paper and supposed to be due to bacteria was probably a virus disease, recently described by Coons et al as ''Savoy''.

Attanasoff, D(imitr)
(Diseases of cultivated plants.) Imprimerie de la Cour, Sofia, University Library No. **137**: 62–181, 1934.

Includes tobacco mosaic and ring spot, potato virus diseases, plum, peach, cherry and apricot mosaic, grape vine mosaic, apple bitter pit, peanut mosaic and curl.

Mosaic of stone fruits. Phytopath. Zeitschr. **8**(3) : 259–284, 1935.

Descriptions of mosaic on apricot, cherry, peach and plum. Infection experiments gave positive results. The disease is spread by *Anuraphis padi.*

Infectious chlorosis of citrus or mal seco. Rapp. Nat. Sec. V., Theme 9, (No. 4) Congr. Intern. Hort. II, Rome, 4 p., 1935.

Believes that *Deuterophoma tracheiphila* follows virus infections and that ''mal seco'' is the same as ''Trabut's infectious chlorosis.''

Mosaic diseases of pome and stone fruits. Rapp. Nat. Sec. V. Theme 9, (No. 5) Congr. Intern. Hort. II, Rome, 6 p., 1935.

Virus diseases of plants: A bibliography. I Supplement. Phytopath. Zeitschr. **10**(4) : 339–463, 1937.

Azevedo, Nearch
Observacoes sobre uma doenca virus en tomateiro. (Observations on a virus disease of the tomato.) Rodriguesia **2**(6) : 209–212, 1936.

A description of a disease resembling the American ring spot but different from the spotted wilt.

Baines, R[ichard] C[ecil]
The status of peach virus diseases in Indiana. Hoosier Hort. **18**(12) : 180–182, 1936.

Popular.

Bald, J[ames] G[rieves]
An F-type potato virus in Australia. Nature **139**(3525) : 674, 1934.

This strain has been reported from Australia. It attacks pepper and *Solanum nigrum.*

————————

The use of numbers of infections for comparing the concentration of plant virus suspensions. I. Dilution experiments with purified suspensions. Ann. Appl. Biol. **24**(1): 33–55, 1937.

The author states that many virus properties can be measured only indirectly in terms of the relative concentration of the virus particles in a suspension and there are two types of reactions which are generally called virological. He describes the one based on "the production of symptoms in a susceptible host plant inoculated with a sample of virus". The other based on "the liberation of specific antibodies into the sera of experimental animals infected with the virus" have been described in previous papers.

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The use of numbers of infections for comparing the concentration of plant virus suspensions. II. Distortion of plant virus dilution series. Ann. Appl. Biol. **24**(1): 56–76, 1937.

A continuance of previous studies, with special reference to distortions in the dilution experiments. The author discusses two types: (*a*) unpurified viruses of tobacco mosaic group and (*b*) potato virus X, viruses of tobacco ring spot, tobacco necrosis, cucumber mosaic and tomato spotted wilt which are less resistant to loss of virulence.

————————

The use of numbers of infections for comparing the concentrations of plant virus suspensions. III. The effect of carbon on the production of lesions by viruses of the tobacco mosaic group. Ann. Appl. Biol. **24**(1): 77–86, 1937.

A comparative study of the spreading power of distilled water suspensions of plant juice, suspensions of finely divided carbon (lamp black) and a commercial spreader. The best results were obtained with the carbon. The experiments were conducted with *Nicotiana glutinosa.*

————————

Virus molecules. Journ. Austral. Inst. Agric. Sci. **3**(2): 93–96, 1937.

The author refers to the confusion resulting from the invasion of virus borders by workers in other fields; reviews the work of Stanley, Beale and others and says:

"Here we have the same two opinions about viruses, as have been held about bacteria, that they are a bridge between lower and higher forms of organization, and that they are derived by a gradation of higher forms. The matter is not likely to be settled soon, not perhaps until a free-swimming pelagic form of virus is found in equatorial waters; even then perhaps diehards of either opinion will still be found."

————————

Investigations on "spotted wilt" of tomatoes. III. Infection in field plots. Bull. Council Sci. & Ind. Res. Australia **106**, 32 p., 1937.

The author discusses (1) the fluctuations in the severity of infections, (2) the influence of the weather on infection and (3) the distribution of infected plants in field plots.

The disease is transmitted almost entirely by *Thrips tabaci* and *Frankliniella insularis*. The development and dispersal of the insect vectors is dependent largerly on weather conditions, especially temperature.

————————, & **Briggs, G. E.**
Aggregation of virus particles. Nature **140**: 111, 1937.

The authors refer to the description by Bawden and others of the shape of the particles of tobacco mosaic virus which has been confirmed by a photograph recently published by Best. They also say that "Further evidence that virus particles, even in dilute solutions, may form chain aggregates is obtained from experiments on the relation between dilution of virus and number of infections caused." This is followed by a brief report of studies with purified preparations.

Ballard, W. S., & Lindner, R. C.
Studies of the little-leaf disease in California. Proc. Amer. Soc. Hort. Sci. (1934) **32**: 1–10, 1935.

Barner, J[ohannes]
Intrazellulare Stäbe bei Viruskranken Tabak-und Kartoffelpflanzen. (Intracellular bodies in virus diseases of tobacco and potato plants.) Nachrichlanbl. Deut. Pflanzenschtzl. **17**(4): 33–34, 1937.

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Intrazellulare Stäbe bei Viruskranken Solanaceen und Cucurbitaceen. (Intracellular bodies in virus diseased solanaceous and cucurbitaceous plants.) Angew. Bot. **19**(6): 553–561, 1937.

Barton-Wright, E[ustace]
Recent advances in Botany, 1932.

This is a text book. The last chapter is devoted to virus diseases.

————————, & **McBain, Alan**
A comparison of the nitrogen metabolism of normal with that of leaf-roll potatoes. Trans. R. Soc. Edin. **57**: 309–349, 1933.

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Possible chemical nature of tobacco mosaic. Nature **133**(3355): 260, 1934.

————————, **et al.**
Virus disease research. Scott. Soc. Res. Plant Breeding, Rpt. Ann. Gen. Meetg. p. 13–17, 1935.

Basset, J., Gratia A(ndré), Machebocuf, M., & Manil, P.
Action of high pressures on plant viruses. Proc. Soc. Expt. Biol. & Med. **38**(2): 248, 1938.

Tobacco mosaic virus was inactivated at 8,000 atmospheric pressure for 45 minutes.

Bawden, F. C.

The virus causing top necrosis (Acronecrosis) of the potato. Ann. Appl. Biol. **23**(3): 487–497, 1936.

The disease can be produced by several viruses. The author has studied the reaction of several hosts to these viruses.

————, **Pirie, N. W., & Spooner, P. C.**

The production of antisera with suspensions of potato virus X inactivated by nitrous acid. Brit. Journ. Expt. Path. **17**(3): 204–207, 1936.

The authors summarize their results as follows: "Antisera indistinguishable from those prepared by injecting suspensions of active virus can be prepared in rabbits by intravenous injection of suspensions of virus X inactivated by nitrous acid. Both fix complement and flocculate with virus suspensions, but not with the sap of healthy tobacco plants and both are equally effective in neutralizing the virus *in vitro.*"

————, ————, **Bernal, J. D., & Fankuchen, I.**

Liquid crystalline substances from virus infected plants. Nature **138**(3503): 1051–1052, 1936.

The authors follow the work of Stanley and say: "We have confirmed these results, but have found that by further purification the protein in neutral aquous solution, can be obtained in liquid crystalline states."

After giving the results of their studies, they said,—"These results have a certain intrinsic interest, but this would naturally be greatly enhanced could it be shown that these rods are in fact virus particles. This conclusion seems to us both reasonable and probable, but we feel it is still not proved, nor is there any evidence that the particles we have observed exist as such in infected sap."

————, & ————

Liquid crystalline preparations of cucumber viruses, 3 and 4. Nature **139**(3517): 546–547, 1937.

The authors report that they were unable to transmit three strains of tobacco mosaic (previously reported by them) to cucumber plants and that cucumber plants are immune to tobacco mosaic virus. They described their most effective method of isolation and give other data.

————, & ————

The relationship between liquid crystalline preparations of cucumber viruses 3 and 4 and strains of tobacco mosaic virus. Brit. Journ. Exp. Path. **18**(4): 275–291, 1937.

The authors made comparative studies of strains 3 and 4 of cucumber mosaic virus with tobacco mosaic virus, aucuba mosaic virus and enation mosaic virus. They say that,—

"Although these viruses have a distinct host range from tobacco mosaic virus, the purified preparations have similar chemical composi-

tions and many properties in common with purified preparations of strains of tobacco mosaic virus; they differ from tobacco mosaic virus however, more widely than the recognized strains of tobacco mosaic virus from each other. The cucumber viruses and the tobacco mosaic viruses have common antigens.''

------------, & ------------
The isolation and some properties of liquid crystalline substances from solanaceous plants infected with three strains of tobacco mosaic virus. Proc. Roy. Soc. London Ser. B. No. **832** p. 274–320, 1937.

The author studied viruses of tobacco mosaic, aucuba mosaic and enation mosaic. They isolated nucleoproteins with characteristic optical properties from all three strains but not from healthy tobacco. They describe the properties of these nucleoproteins.

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A plant virus preparation in a fully crystalline state. Nature **141**: 513–514, 1938.

Specific proteins believed to be virus have been isolated and found to lack three dimensional regularity characteristics of true crystals.

------------, & ------------
Liquid crystalline preparations of potato virus X. Brit. Journ. Exp. Path. **19**(1): 66–82, 1938.

The authors describe methods for the isolation of nucleoprotein from *Nicotiana Tabacum. N. glutinosa* and *Lycopersicum esculentum.* The virus is less filterable after purification than in the untreated sap. These are two types of inactivation,—''one leads to a loss of infectivity without changing the optical properties or serological reactions, where as the other denatures the protein and destroys all three.''

Discussion on recent work on heavy proteins in virus infection and its bearing on the nature of viruses. Proc. Roy. Soc. Med. **31**: 199–210, 1938.

A discussion of protein crystals.

Bayma, A. Da Cunha
(Mosaic disease of sugar-cane in the State of Ceará, Brazil.) O Compo (Río de Janeiro) **4**(7): 74–78, 1938.

Beale, Helen Purdy (see **Purdy Beale, Helen Alice**)

Bechhold, H.
Enzyme oder Lebewesen? (Ferment or living entity?). Kolloid Zeitsch. **66**(3): 329–340, **67**(1): 66–79, 1934.

The author concludes that viruses are not enzymes.

------------, **& Erbe, F.**
Versuche zur aufklärung des Mechanismus der "Kupferprobe" zur feststellung des Kartoffelabbaus. (Attempts at the explanation of the mechanism of the copper test for the determination of potato degeneration.) Phytopath. Zeitschr. **9**(3): 259–296, 1936.

There was no appreciable difference between diseased and healthy potatoes.

Bechwith, C[harles] S[teward]
False blossom. Amer. Cranbery Growers' Assoc., Proc. Ann. Meetg. **6**(1935): 25–26, 1936.

Popular appeal for control.

Bell, A[rthur] F[rank]
Fiji disease. Eradication of diseased stools in young sugar cane. Cane Grow. Quart. Bull. Queensland **4**(2): 39, 1936.

Report of the Division of Entomology and Pathology. Rpt. Bur. Sugar Exp. Sta. Ind. **1935**: 19–27, 1936.

Gives data on Fiji disease and chlorotic streak (fourth disease.)

Save P.O.J. 2878. Queenland Agric. Journ. **48**(6): 714–718, 1937.

This variety is threatened by the Fiji disease.

Fiji disease of sugar cane. Proc. Queensland Soc. Sugar Cane Tech. **9**: 211–218, 1938.

Bellair, G.
Chlorosis of peaches and roses. Rev. Hort. & Agric. Afrique Nord **38**: 261–264, 1934.

Benes, G.,
Court-noué et chlorose. (Court-noué and chlorosis.) Prog. Agr. & Vitc. **102**(29): 81–84, 1934.

Benllock, M., & Domínguez, F.
La enfermedad de los pimentales en Aldeanueva del Camino. (Virus disease of chillies). Bol. Pat. Veg. & Ent. Agric. **7**(7): 27–30, 1934.

Description of this disease of occurrence in Spain, known as "niebla nueva" and "niebla vieja", early and late blight, probably due to a virus..

Bennett C[arlyle] W[ilson], & Esau, Katharine
Further studies on the relation of the curly top virus to plant tissues. Journ. Agric. Res. **53**(8): 595–620, 1936.

"Anatomical evidence indicates that the curly top virus invades the phloem of the entire vascular system of beet and tobacco. In susceptible

varieties of beet the disease is characterized by necrosis of the phloem and hyperthrophy of the phloem and pericycle. Liquid content of the phloem moves through the intercellular spaces of the extraphloem tissue and accumulates on the surface of petioles and leaves.''

There is less exudation in resistant beets and no abnormalities. The authors also made a study of this disease on tobacco plants. Also a study of the virus in the seeds.

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Correlation between movement of the curly top virus and translocation of food in tobacco and sugar beet. Journ. Agric. Res. **54**(7) : 479–502, 1937.

This paper gives the results of studies of the movements of curly top virus in the beet, *Nicotiana tabacum* and *N. glauca*. The rate of movement was extremely variable and the author concludes that ''The way in which the curly top virus invades the plant indicates that virus movement bears little or no relation to virus multiplication or to virus concentration gredients, but is dependent on physiological processes that take place in the normal plant.''

\-\-\-\-\-\-\-\-\-\-\-\-, **& Wallace, H. E.**

Relation of the curly top virus to the vector, *Eutettix tenellus*. Journ. Agric. Res. **56**(1) : 31–51, 1938.

A viruliferous insect can pick up the virus in one minute and transmit to a healthy plant in one minute. A non-viruliferous insects may pick up enough virus to transmit by feeding on diseased plants for two days. Fasting reduces the power to transmit. Virus was found in the blood, salivary glands, feces and alimentary tract of the insects. Ability to cause infections decreased over a period of 8 to 10 weeks. Some insects with low charge of virus lost power to transmit in 54 days. Several other species of insects picked up the virus but lost it in a short time.

Berkeley, G[arven] H[ugh]

The ''degeneration'' of strawberry. III. The phenomenon of root rots in connection with strawberry degeneration. Imp. Br. Fruit Prod. Tech. Comm. **5**: 16–19, 1934. (East Malling Res. Sta. 22nd. Ann. Rpt. **1934**: 65, 1935.)

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Suspected mosaic disease of strawberry. Canada Progress Rpt. Dom. Bot. **1931–34**: 58, 1935.

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A strain of the virus which causes streak in tomato. Canadian Journ. Res. **C 14**: 419–424, 1936.

The author gives the results of experiments with these strains of the virus causing tomato streak—(*a*) tomato streak virus K, (*b*) tomato streak virus I (Ontario strain) and (*c*) tobacco virus I. The last can be used for immunizing against the other two. The first and second are believed to be strains of the last.

Mosaic and ring spot, two dahlia diseases. Canada Hort. Floral Ed. **60**(2): 25–26, 1937.

Popular.

Prevention of virus diseases of greenhouse-grown tomatoes. Canada Dept. Agric. Circ. **118**, 7 p., 1937.

A study of losses due to several virus disease in greenhouses and recommendations for their control.

Prevention of tobacco mosaic in Ontario. Canada Dept. Agric. Circ. **119**, 7 p., 1937.

Dahlia mosaic and its control. Canada Hort. **61**(5): 146–147, 1938.

Popular.

Berkner, F. W., & Hecker, G.
Die Nachwirkung von verschiedenen Kalidungeru und Pflanzeiten des vorjahves auf den Pflanzgutwert von Kartoffeln. (The after-effect of various potash manures and planting times in the previous year on the value of potatoes for seed.) Landw. jb. **82**(1): 125–139, 1935.

The best results with respect to degeneration were on potatoes without potash.

Ein weiterer Beitrag zur Frage des Abbauproblems der Kartoffel. (A further contribution to the degeneration problem in potatoes.) Pflanzenbbau **12**(7): 243–274, 1936.

A review of the literature and summarization of recent studies.

Zur Frage des Kartoffel-Abbaus. Ist es möglich, die neigung zum Kartoffel-Abbau-limduszuschieben? (On the question of potato degeneration. Is it possible to postpone the tendency to potato degeneration?) Dutsch. Landw. Pr. **63**(4): 167, 1936.

The symptoms are more sevgre on the early crops.

Bernal, J. D., & Fankuchen, I.,
Structure types of protein "crystals" from virus-infected plants. Nature (London) **139**(3256): 923–924, 1937.

A study of the dimensions of the molecules.

Best, Rupert J.
The effect of environment on the production of primary lesions by plant viruses. Journ. Australian Inst. Agric. Sci. **1**(4): 159–161, 1935.

A study of the effect of light on the virus of tomato spotted wilt and tobacco mosaic. Spotted wilt in tobacco is inhibited by bright sunlight and controlled by artificial light. Tobacco mosaic virus in *Nicotiana glutinosa* developed more lesions in the glass house than in the laboratory. More lesions are observed at 20°C than at 15°C.

-------------, & **Samuel, Geoffrey**

The reaction of the viruses of tomato spotted wilt and tobacco mosaic to the pH value of media containing them. Ann. Appl. Biol. **23**(3) : 509–537, 1936.

The pH value must be taken into consideration or the results will be erroneous because certain pH values cause inactivation while others do not. A study of the pH relationships may aid in classification. Two viruses in a mixture may be separated by the use of the pH values. The determination of the host range or the occurrence of the virus in various parts of a plant by reinoculation is not sufficient. The negative results may be due to inactivation of the virus by acids or other substances. The pH must be taken into consideration. The activity pH curves resemble enzyme curves more than living organism curves. A virus may be inactivated at certain pH values as rapidly as formed.

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The effect of various chemical treatments on the activity of the viruses of tomato spotted wilt and tobacco mosaic. Ann. Appl. Biol. **23**(4) : 759–780, 1936.

The authors give a brief review of the subject, describe their experiments in full. In the summary they say: "It is concluded that secondary oxidation products caused the inactivation observed." "Attempts to reactivate virus which had been inactivated by exposure to air or by means of Hg Cl_2 were unsucessful." It has been shown that the inactivating effects observed are due to an action on the virus itself.

Precipitation of the tobacco virus complex at its isoelectric point. Australian Journ. Expt. Biol. Med. Sci. **14**(1) : 1–13, 1936.

A study of the precipitation of ordinary tobacco mosaic (tobacco virus I) with buffer solutions at varying hydrogen-ion concentrations.

Studies on a fluorescent substance present in plants. I. Production of the substance as a result of virus infection and some applications of the phenomenon. Australian Journ. Expt. Biol. & Med. Sci. **14**(3) : 199–213, 1936.

This fluorescence was observed when the plants were examined with ultraviolet light but was found to be present in other types of injuries.

The effect of light and temperature on the development of primary lesions of the viruses of tomato, spotted wilt and tobacco mosaic. Australian Journ. Expt. Biol. & Med. Sci. **14**(3) : 223–239, 1936.

A study of the environmental effects of the viruses of the tomato and tobacco mosaic on *Nicotiana tabacum* and *N. glutinosa.*

Neither sunlight nor artificial light appeared to affect tobacco mosaic virus lesions quantitatively.

Sunlight was found to exert and inhibiting action on the appearance to tomato spotted wilt lesions on *N. tabacum.* A similar but much feebler effect was observed with artificial light.

\-\-\-\-\-\-\-\-\-\-\-\- Prevention of virus disease of greenhouse-grown tomatoes. Canada Dept. Agric. Circ. **118**, 7 p., 1937.

\-\-\-\-\-\-\-\-\-\-\-\- The relationship between the activity of tobacco mosaic virus suspensions and hydrion concentration over the pH range 5–10. Australian Journ. Expt. Biol. & Med. Sci. **14**(4): 323–328, 1936.

The virus was inactivated at about pH. 7.8 and the fraction inactivated became larger with increasing pH values up to pH 10.2. ''It is concluded that inactivation of the virus is associated with the naturalization of acidic groups.''

\-\-\-\-\-\-\-\-\-\-\-\- Investigations on plant virus diseases. Waite, Agric. Res. Inst. Univ. Adelaide Rpt. **1933–36**: 1–7, 1936.

A review of the author's work on spotted wilt of tomato.

\-\-\-\-\-\-\-\-\-\-\-\- Visible mesomorphic fibres of tobacco mosaic virus in juice from diseased plants. Nature **139**(3519): 628–629, 1937.

The author refers to a short paper in Nature by Bawden, Pirie, Bernal and Fankuchen on ''Liquid crystalline substances from virus-infected plants.'' He states that he has arrived at similar conclusions and describes long mesomorphic fibers which he obtained. When agitated the fibres break into short rods. He concludes by saying—''The circumstance that under certain conditions the fibres have the appearance of short needles or rods raises the question as to whether the needles obtained by crystallization from ammonium sulphate solution, as first worked out by Stanley, may not in fact be short mesomorphic rods rather than true crystals.''

\-\-\-\-\-\-\-\-\-\-\-\- Artificially prepared visible paracrystalline fibers of tobacco mosaic virus nucleoprotein. Nature **140**: 547, 1937.

The author refers to a previous article containing photographs of mesomorphic or paracrystalline fibers obtained from tobacco mosaic virus. He now reports obtaining similar crystals by using a suitable pH (5 being most satisfactory) and by precipitation with 15 per cent ammonium sulphate at pH 7.

\-\-\-\-\-\-\-\-\-\-\-\- Investigations on plant virus diseases. Waite Agr. Res. Inst. Univ. Adelaide. Rpt. **1933–36**: 84–90, 1937.

This paper is a discussion of tomato spotted wilt and tobacco mosaic. The author summarizes his work as follows,—

"Viewing the plant viruses as a class and taking into account the property possessed by them in common with other viruses, of being able to multiply in living cells, and their wide range in size, the most logical picture of them appears to be of that class of complex organic structures built on a protein base with a large number and variety of active prosthetic groups, these latter entering into the biochemical reactions through which the viruses become evident and which are at same time concerned with processes which we have come to associate with life and living. This picture is essentially similar to that of Alcock's "living molecules" and in the present state of our knowledge seems to fit the facts best and to form a logical conception of this group of entities."

The quantitative estimation of relative concentrations of the virus of ordinary and yellow tobacco mosaics and tomato spotted wilt by the primary lesion method. Australian Journ. Exp. Biol. & Med. Sci. **15**(2): 65–79, 1937.

"It is concluded that, on account of the number of factors involved, we could scarcely expect a single equation to represent the relationship between lesion number and virus concentration over the whole range. However, in practice under controlled conditions both with respect to inocula and test plants, that portion of the curves over which direct proportionality between lesion number and virus concentration holds, provides a useful working range in which to estimate relative concentrations with a reasonable degree of accuracy."

On the presence of an "oxidase" in the juice expressed from tomato plants infected with the virus of tomato spotted wilt. Australian Journ. Expt. Biol. & Med. Sci. **15**: 191–199, 1937.

The author summarizes his work in part as follows,—

"It has been shown that the juice expressed from the leaves of tomato plants infected with the virus of tomato spotted wilt contains an 'oxidase' enzyme tentatively identified as tyrosinase) which catalyses the oxidation of phenol, catechol, guinol and tyrosine in the presence of air. The reaction does not proceed to a demonstrable extent in suspensions of juice expressed from comparable parts of healthy plants but it does in suspensions of root juice."

The chemistry of some plant viruses. Australian Chem. Inst. Journ. & Proc. **4**(10): 375–392, 1937.

The author discusses the viruses of spotted wilt of tomato and tobacco mosaic with special reference to the chemical properties. In his summary he says,—

"To sum up, it appears that there is no sharp break between living and non-living matter, and that viruses may be regarded as complex chemical structures, built on a protein base with a large number and

variety of prosthetic groups, through which they enter into those reactions by which they become evident and by which they multiply—reactions which we have come to associate with life and living. If we accept this view, then viruses may be regarded as living molecules of graded complexity of structure and organization covering the transition between the architecture of the larger non-living chemical molecules and the architecture of the simplest living cell.''

Beurnier.,
La rosettee de l' arachide. (Peanut rosette.) Bull. Mat. Grass. Inst. Colon. Merseille **20**(8) : 201–205, 1936.

Popular.

Bewley, W[illiam] F[leming], & Corbett, W[ilfred]
Mosaic disease investigation. Ann. Rpt. Expt. & Res. Sta. Nurs. & Mark. Gard. Industr. Deve. Soc. Cheshunt **15**: 51–52, 1930.

A paper on the control of cucumber and tomato mosaic by the use of clean seed.

Spotted wilt of tomatoes. Cheshunt Expt. Sta. Cheshunt, Hert. Circ. **1**, 3 p., 1933.

Popular.

Some factors which affect the quality of tomatoes. Fruit Grow. Flor. & Mark. Gard. **83**(2) : 748–750, 1937.

A popular paper. The first part is a discussion of virus diseases.

Bitancourt, A[gegislan] A.
As doencas de virus dos citrus (Virus diseases of Citrus.) Biológico **1**(8) : 255–262, 1935.

The author states that studies based on the relevant literature and his own observations show evidence enough to consider citrus psorosis, leprosis, ring blotch and zonate chlorosis as produced by viruses.

Black, L. M.
Some insect and host relationship of potato yellow dwarf virus. Phytopathology **26**(1) : 87, 1936.

A study of potato yellow dwarf in New York. Cornell Agric. Expt. Sta. Memoir **209**, 23, p. 1937.

A very thorough study of this disease, including symptoms, insect, transmission, hosts, and overwintering.

Mechanical transmission and properties of the potato yellow dwarf virus. Phytopathology (Abstract) **28**(1) : 3, 1938.

Blaringhem, L[ous Florimond]
Nouveau cas de mosaïque presente par un hybride de giroflées (*Cheiranthus chevri* et *Erysimum cheirantoides*.) A new case

of mosaic on a hybrid of wall flower (*Cheiranthus chevri* and *Erysimum cheirantoides.*) Comp. Rend. Acad. Sci. **203**(2): 1039–1042, 1936.

Blood, H[erbert] L[oren]
Curly top (Western yellow blight) of tomatoes in Utah. U.S.D.A. Plant Disease Rpt. **18**(11): 131–133, 1934.

The tomato curly top situation in Utah. U.S.D.A. Plant Disease Rept. **19**(11): 191–192, 1935.

The Utah tomato disease situation in 1935. U.S.D.A. Plant Disease Rept. **20**(6): 96–102, 1935.

Contains important data on curly top of sugar beet. Also a note on mosaic and streak of tomato.

Curly top of tomato in Utah. U.S.D.A. Plant Disease Rpt. **22**(14): 226, 1936.

A record of this disease in Utah for the third consecutive year.

Blümke.,
Wie lässt sich der Kartoffelabbau bekämpfen? (How can potato degeneration be combated? Mitt. Landw., Berlin. **52**(49): 1048–1050, 1937.

The author urges a thorough roguing during the month of May. The most important vector is *Lygus pabulinus.*

Bodine, E[dward] W.
Occurrence of peach mosaic in Western Colorado. Journ. Colorado–Wyoming Acad. Sci. **2**(1): 49, 1935.

The disease was found in Colorado May 19, 1934. Only previous records are from Texas.

------------, **& Durrell, L. W.,**
The Maynard plum—a carrier of the peach mosaic. Science **86**(2221): 81, 1937.

Budding and root-grafting tests indicate that plums may be carriers of this disease.

The Maynard plum—A carrier of the peach mosaic. Phytopathology (Abstract) **27**(9): 954, 1937.

Abstract of paper read before the 21st Annual meeting of the Pacific Division of the American Phytopathological Society. The plum was suspected of being a carrier. It was proved to be a carrier by grafting buds from plum to healthy peach trees.

Bonazzi, A[ugusto]
Study on sugar cane mosaic. Science. **64**(1665): 529–530, 1926.

Boning, Karl

Über den Einfluse der Anionen der Düngesalze auf Abbau and Abbaukrankheiten der Kartoffel. (On the influence of the anion of the fertilizer salts on degeneration and degeneration disease of the potato.) Angew. Botanik **17**(2): 323–335, 1935.

Boning-Senbert, E.,

Die Mosaikkrankheit der Gurken. (Mosaic disease of cucumber.) Prakt. Blätt. Pflanzenb. u. Pflanzensch. **33**(9–10): 215–221, 1933–34.

Boyd, O[ran] C[ecil]

Losses due to leaf roll in potato variety test. U.S.D.A. Plant Disease Rept. **20**(21): 333, 1936.

A brief note.

Boyle, L[ytton] W., & McKinney, H[arold] H[all]

Trichomes of incidental importance as centers for local virus infections. Science **85**(2210): 458–459, 1937.

The authors report that the trichomes are of less importance than the epidermal cells.

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Local virus infections in relation to leaf epidermal cells. Phytopathology **28**(2): 114–122, 1938.

This is a study of infections in trichomes and surface epidermal cells. The authors used common tobacco mosaic and inoculated leaves of *Nicotiana glutinosa, N. rustica* and *Capsicum frutescens*. The work involved mutilation of surface cells and trichomes and immediate inoculation.

Boysen-Jensen, P.,

Die Stoffproduktion der Pflanze (Blattrollkrankheit). Jena 108 p., 1932.

Branas, J., & Bernon, G.

Contribution a l'etude du court-noué de la vigne. (Contribution to the study of "court-noué" of the vine.) Rev. Path. & Ent. Agr. **22**(1): 19–24, 1935.

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Contribution a l'etude du court-noué de la vigne. (Contribution to the study of "court-noué" of the vine.) Ann. Ecole Nat. Agr. (Montpellier) n.s. **23**(3–4): 150–154, 1935.

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Troisiéme contribution a l'étude du court-noué de la vigne (Third contribution to the study of "court-noué" of the vine.) Rev. Vitic (Paris) **85**(2216): 469–472, 1936.

The leaves from the diseased vines contain a higher content of glucosides than the leaves of healthy plants.

————————, ————————, & **Levadoux, L.**
Note sur la transmission par le sol de la dégénérescence de la vigne. (Note on the transmission of the degeneration of the vine by the soil.) Rev. Vitic. (Paris) **87**(2258) : 263–268, 1937.

This is a discussion of the importance of *Phylloxera* in the spread of degeneration diseases such as "court-noué," "arriciamiento," "reisigkrankheit," fasciation, anomalie and panachure.

Brentzel, W. E.
"Purple top" wilt of potato in North Dakota. U.S.D.A. Plant Disease Rept. **22**(2) : 44–45, 1938.

This disease has some symptoms that indicate that it is due to a virus, but this has not been definitely proven.

Bremer, H.
Zur Krauselkrankheit der Pelargonien. (On the curl disease of *Pelargonium.*) Blemen—u Pflansenbau. **48**(2) :—, 1933.

Brierley, Philip, & McWhorter, Frank P[aden]
A mosaic disease of iris. Journ. Agric. Res. **53**(8) : 621–635, 1936.

This disease was found to be widely distributed on the Pacific Coast. Intracellular bodies were present. Transmitted by tissue, by juice and by *Illinoia solanifolia* and *Myzus persicae.*

————————, & **McKay M[arion] B[ertice]**
Experiments with aphids as vectors of tulip breaking. Phytopathology **28**(2) : 123–129, 1938.

These studies show that the two viruses distinguished by McWhorter are transmitted by *Myzus persicae* and *Macrosiphum (Illinoia) solanifolia.* *Myzus circumflexus* transmitted in one trial. *Myzus solani* previously reported as a vector fails to transmit.

Briton-Jones, R. H., & Staniland, L. N.
The effects of strawberry aphids on the strawberry plant. Journ. Pom. & Hort. Sci. **6** : 127–136, 1927.

This paper probably referred to a virus carried by the aphids.

Bruner, S[tephen] C[ole]
Experimento sobre el daño que ocasione el mosaico a la caña Cristalina (Experiment on the damage of mosaic to Crislina cane.) Cuba Est. Agron. Expt., Santiago de las Vegas, Dept. Entom. & Fitopat. Ann. Rpt. **1929–30** : 41–46, 1931.

Burns
Über das Durchwachsen der Kartoffeln. D. Kartoffelbau **20** : 38–39, 1936. (D. Kartofellhandel **22**(27) :—, 1936.)

Bukart, A., & Soriano, S.
Observaciones sobre el mosaico de las lèguminosas. (Observations on the mosaic of luguminous plants.) Rev. Agron. Argentina **1**(3) : 229–230, 1934.

Burnet, F. M., Keogh, E. V., & Lush, D.
Immunology of plant viruses. The immunological reactions of the filterable viruses. Australian Journ. Expt. Biol. & Med. Sci. (3 suppl.) **15**: 279–283, 1937.

Burr, W. W.
A study of potato spindle tuber and combinations of spindle tuber with other degeneration diseases. Nebraska Agric. Expt. Sta. Ann. Rpt. **42**: 30–31, 1929.

Busse, (G.)
Zur Frage der Kartoffelabbaues. (On the question of potato degeneration.) Deutsche Landw. Presse **63**(17): 207, 1936.

Kartoffel–Abbau, Pflanzzeit und Ernteverfahren, Deutsche Landw. Presse **63**: 566, 1936.

Butler, E[dwin] J[ohn]
Views on the "spike" disease in sandal-wood. Reported by M. Muthannah, 6 p., 1904.

The nature of immunity in plants. Third Int. Cong. Comp. Path. Rpt. **1**(2): 1–16, 1936.

The author recognizes five types of acquired immunity, viz. (1) following initial infection in the case of virus diseases, (2) local immunity following initial infection, (3) immunity following vaccination in which antibodies may be present, (4) intracellular immunity and (5) immunity symbiosis.

Butler, O[rmond] R[ourke]
Potato disease experiments. New Hampshire Agric. Exp. Sta. Ann. Rpt. 1934, (Bull. 284), p. 15, 1935.

A report of progress on temperature studies on mosaic of potatoes.

Caldwell, John
Factors affecting the formation of local lesions by tobacco mosaic virus. Roy. Soc. (London) Ser. B, **119**(815): 493–507, 1936.

The production of lesions may be reduced or abolished by the addition of certain substances (normal serum) to the juice containing the virus. These inhibitory substances may act on the virus by neutralizing its activity or the leaves by reducing susceptibility. The author proposes a method by which a distinction can be made.

The agent of virus disease in plants. Nature **138**(3503): 1065, 1936.

This is a brief paper in which the author makes reference to his own published work and to the work of Stanley. The virus moves out of the young leaves rapidly. The movement of the food material has very little effect on the movement of the virus. The movement of the virus in protoplasmic strands is confirmed.

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The movement of the agent in the plant. Deux. Cong. Int. Path. Comp. (Paris) 1931. II Compt. Rend. et. Comm. p. 480, 1931.

A note in English.

\-\-\-\-\-\-\-\-\-\-\-\-\-, **& Smith, Kenneth M[anley]**
An air-borne plant virus. Nature **139**(3522) : 761–762, 1937.

A criticism.

\-\-\-\-\-\-\-\-\-\-\-\-\-, **& James, A. L.**,
An investigation into the "stripe" disease of narcissus. I. The nature and significance of the histological modifications following infection. Ann. Appl. Biol. **25**(2) : 244–253, 1938.

There is a wide variation in the appearance of infected plants. It inhibits or destroys chlorophyll, stimulates cell division and cell growth. Inclusion bodies resemble X-bodies.

Caley, D. M.
Panachure infectiouse (breaking) des tulipes. (Infectious variegation (Breaking) of tulips.) Deux. Cong. Int. Path. Comp. (Paris) 1931, II Compt. Rend. et Com. p. 446–447, 1931.

A brief review.

Calinisan, M[elanio] R., & Hernández, Crispiniano C.
Studies on the control of abaca bunchy-top with reference to varietal resistance. Phil. Journ. Agric. **7**(4) : 393–408, 1936.

A study on varietal resistance and rouging. Some varieties are more resistant than others.

Caminha, Adriao
Sugar cane diseases in Brasil. Brasil Assuc. **7**(4) : 209–213, 1936. (Facts About Sugar (Abstract) **31**(12) : 471, 1936.)

Contains records of well known virus diseases.

Carne, W[alter] M[ervyn]
Spotted wilt of tomatoes. Journ. Dept. Agric. West Australia **2**(5) : 58, 1928.

\-\-\-\-\-\-\-\-\-\-\-\-\-, **& Martin, D.**
Preliminary experiments in Tasmania on the relation of internal cork of apples and cork of pears to boron deficiency. Journ. of the Counc. for Sci. and Inds. Res. **10**(1) : 47–56, 1937.

This paper is included in the bibliography although there is some difference of opinion as to whether the disease is caused by a virus. This paper gives the results of fertilizer experiments for the control of the disease.

Carsner, E[ubanks]

Seasonal and regional variations in curly top of sugar-beets. Science **63**: 213–214, 1926.

Gives the results of studies on relation of weather to outbreaks of the disease.

————————, & **Piemeisel, R[obert] L[ouis]**

Sugar-beet curly top's spread aided by vast increase in host weeds. U. S. Dept. Agric. Year Book **1931**: 791–793, 1931.

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Results from U. S. No. 1 resistant beet seed. Facts About Sugar **30**(2): 70, 1935. (Landb. Tijdschr. **48**(584): 179, 1936.)

Carter, W(alter)

Seasonal and regional variations in the curly top of sugar beets. Science **63**(1625): 213–214, 1926.

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The toxic dose of mealy-bug wilt of pineapple. Phytopathology **27**(10): 971–981, 1937.

A study of *Pssudococcus brevipes* (Ckll.) as a carrier of the causal agent of this disease. The percentage of infection increases with number of insects but is not directly proportional to the number. There is a point of dosage beyond which there is a very little increase. Variability between different experiments is very high.

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Aphis transmittal of *Commelina nudiflora* Linnaeus mosaic to pineapple. Ann. Ent. Soc. Amer. **30**(1): 155–158, 1937.

The virus of *C. nudiflora* is transmissible to the pineapple where it produces a spot very similar to yellow spot. The vectors are *Aphis gossypii, Myzus persicae* and *Macrosiphum solanifolii.*

Casella, Dominico

L' apiature del limone e la selezione gemmaria. (Variation in lemons and bud selection.) Ann. R. Sperim Agrumicolt. e Futticolt. Aciseale **1**: 47–49, 1933.

The author describes corrugated or ribbed strains of lemons which he believes be due to a virus. This character is transmitted by an aphid, *Toxoptera aurantii.*

Cation, Donald

An infectious rosette of peach trees. Michigan Agric. Exp. Sta. Quart. Bull. **16**(2): 79–84, 1933.

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The role of plums in the spread of peach virus diseases. Michigan State Hort. Soc. Ann. Rpt. **65**: 61–63, 1935.

Popular.

Catoni, G.
Malattia e degenerazione della patata. (Disease and degeneration of the potato.) Boll. R. Stat. Pat. Veg. **15**(1) : 234, 1935.

Brief commentary on a manual published under the above title.

Malattia e degenerazione della patata. (Disease and degeneration of the potato.) A. G. Saturnia, Trento, 140 p., 1935. (Review in Riv. Agric. Rome **31**: 157–158, 1935.)

La degenerazione della patata (Degeneration of the potato.) First Convegno Nazionale per l'Incremento della Produzione della Patate etc., p. 29–30, 1935.

La degenerazione della patata. (Potato degeneration). Atti del Primo Convegno Incremento della Prod. della Patata, Como, p. 82–106, 1935.

Programma per la rigenerazione della patata e la produzione di buena semente nella Provincia di Trento. (Program for the regeneration of the potato and the production of good seed in the Trenton Province.) Trento, 8 p., 1936.

Cavanagh, A. E.
Report on phony peach disease control. Proc. Tennessee State Hort. Soc. **32**: 48–53, 1937.

A popular review. The disease has been known for 50 years or more.

Cayla, V.
La canne á sucre et le "sereh" á Java. (Sugar cane and "sereh" in Java.) L'Agron. Colon. (Paris) **22**(183) : 81–86, 1933.

Chabrolin, C.
Notes phytopathologiques Tunisiennes. (Tunisian phytopathological notes.) Bull. Soc. Hist. Nat. Afr. Nord. **26**(2) : 26–41, 1935.

Mosaic of *Vicia faba.*

Chamberlain, E[dward] E[dinborough]
Pea-mosaic. Host range and methods of transmission. New Zealand Journ. Sci. & Tech. **18**(6) : 544–556, 1935.

A virus disease of crucifers. New Zealand Journ. Agric. **53**(6) : 321–330, 1936.

A description and discussion of this disease which attacks *Brassica rapa, B. cernua, B. Japonica, B. Napobrassica, Sinapsis arvensis, Raphanus* sp. *B. napus* var. *chinensis, S. alba B. nigra, B. napus* var. *typica, B. oleracea* var. *bullata, B. oleracea* var. *botrytis* and *B. oleracea* var. *acephala.* It is transmitted by *Brevicoryne brassica* and *Myzus persicae.*

Nicotine content of tobacco. New Zealand Journ. Sci. & Tech. **18**(8): 628–637, 1937.

Mosaic causes reduction in amount of nicotine.

Pea insects. Its systems, economic significance, and preventative treatment. New Zealand Journ. Agric. **54**(3): 129–136, 1937.

A description of the disease and list of host plants. It is transmitted by *Myzus persicae. Aphis rumicis* and *Macrosiphum gei.* The virus overwinters in red-clover.

Tobacco-mosaic. Its appearance, cause, and control. New Zealand Journ. Agric. **55**(3): 163–174, 1937.

Tobacco mosaic. New Zealand Journ. Sci. & Tech. **19**(4): 209–226, 1937.

Yellow blotch-curl: a new virus disease of the red rasberry in Ontario. Canada Journ. Res. C. (Bot. Sci.) **16**(3): 118–124, 1938.

Raspberry virus diseases and certification. Canad. Hort. (Fruit ed.) **60**(5): 145–146, 1937.

Popular.

Chandler, W. H., Hoadland, D. R., & Hibbard, P. L.
Little-leaf or rosette of fruit trees. III. Proc. Amer. Soc. Hort. Sci. 1933, **30**: 70–86, 1934.

Little-leaf or rosette of fruit trees. IV. Proc. Amer. Soc. Hort. Sci. **32**: 11–19, (1934), 1935.

Chardon C[arlos] E[ugenio]
Informe sobre el "mosaico" de la caña de azúcar al Señor Ministro de Agricultura y Comercio, Dr. Manuel José Vargas. (Report of sugar cane mosaic to the Minister of Agriculture and Commerce, Dr. Manuel José Vargas.) Agricultura (Bogotá) **9**(6): 108–120, 1937.

Observations on the mosaic disease in Colombia.

Orígenes y desenvolvimiento del mosaico de la caña de azúcar. (Origin and development of sugar cane mosaic.) Rev. Agric. Puerto Rico **28**(4): 749–753, 1937.

Extract from a paper read before "La Sociedad de Agricultores de Colombia", Jan. 22, 1937.

El mosaico de la caña de azúcar en Colombia. (Sugar cane mosaic in Colombia). Rev. Agric. Santo Domingo, **28**(92): 239–242, 1937.

Chattergee, N. C.

Entomological investigations on the spike disease of sandal. Pentatomidae (Hempt.) Indian Forest. Rec. **20**(9): 1–31, 1934.

A study of the insect fauna of the sandal.

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Entomological investigations on the spike disease of sandal (25), *Lepidoptera*. Indian Forest Rec. Ent. **1**(10): 185–204, 1935.

A list of species collected.

————————, **& Ramakrishna Ayyar, T. V.**

Entomological Investigations on the spike disease of sandal (26), *Coccidae* (Homopt.), Indian Forest Rec. Ent. **1**(12): 233–242, 1936.

A list of species collected.

Chester, K[enneth] S[tarr]

The problem of acquired immunity of plants. Quart. Rev. Biol. **8**: 129–154, 275–329, 1933.

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A serological estimate of the absolute concentration of tobacco mosaic virus. Science **82**: 17, 1935.

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Serological tests with Stanley's crystalline tobacco-mosaic protein. Phytopathology **26**(8): 715–734, 1936.

The author gives the following summary:

"1. The Schultz-Dale method was applied to materials containing several plant viruses, including tobacco-mosaic virus. It was found that the viruses tested gave no anaphylactic reactions. This was shown both by absorbing the muscles with healthy-plant juices prior to testing for virus reaction, and by using as virus hosts for sensitization and testing, respectively, two species of plants so remotely related that the virus was the only common serological element. Healthy-plant proteins, on the contrary, were highly anaphylactogenic. The proteins of healthy tobacco and healthy tomato were very similar serologically.

"2. The uteri of animals sensitized with healthy-plant proteins reacted to solutions of crystalline tobacco-mosaic virus protein, and the uteri of animals sensitized with the crystalline protein reacted to dilute extracts of healthy-tobacco proteins. Complement-fixation tests confirmed the anaphylactic tests in showing cross reactivity between the crystalline protein and healthy-plant protein. The evidence indicates that this cross reactivity is due not to a serological affinity between virus and healthy-tobacco protein, but to the presence in the crystalline material of a contaminating protein serologically allied or identical to protein of the healthy tobacco plant.

"3. Precipitin and complement-fixation experiments revealed the presence in the crystalline materials of considerable quantities of virus.

"4. Precipitin tests of the sera from sensitized guinea pigs showed that in a given animal tobacco-mosaic virus may be a highly active precipitinogen but inactive anaphylactically, while healthy-tobacco pro-

teins in the same animal may be comparatively inert in producing precipitins but highly active in stimulating anaphylaxis. This implies that the mechanisms of the two reactions are different, although the same antibodies may be concerned in both. It is possible that the molecular size or solubility of the respective antigens underlies this difference in antigenic manifestation.''

------------ Separation and analysis of virus strains by means of precipitin test. Phytopathology **26**(8) : 778–785, 1936.

The author concludes by saying, ''From the evidence reported above it is concluded that the absorption technique used permits the diferentiation of strains of this same virus type. By using such a technique it has been shown that serological differences exist among certain strains of tobacco mosaic virus. Strains of latent potato-mosaic virus also separable from one another serologically. It was found that the precipitin absorption technique described, not only serves to distinguish virus strains, but also give some index of the constitution of the diferent virus.''

------------ Liberation of neutralized virus and antibody from antiserum precipitates. Phytopathology **26**(10) : 949–964, 1936.

This paper gives the results of experiments which are summarized in part as follows:

''These findings demonstrate that when tobacco mosaic virus neutralized by its specific immune serum, the virus is not destroyed but is held in an impotent non-inefective condition from which it may be liberated if the antibodies are destroyed by pepsin digestion.''

------------ The limitations of plant virus serology. Phytopathology (Abstract) **27**(2) : 124, 1937.

------------ A critique of serology I. The nature and utilization of phytopathological procedures. Quart. Rev. Biol. **12**(1) : 19–46, 1937.

------------ A simple and rapid method for identifying plant viruses in the field. Phytopathology **27**(6) : 722–727, 1937.

The author describes a method for the determination of viruses in the field which is much shorter and easier than the laboratory blood or precipitin test.

------------ Serological studies of plant viruses. Phytopathology **27**(9) : 903–912, 1937.

The author has classified 34 viruses into 8 groups. Twenty-one viruses were found to be nonreactive. The author used a modified precipitin method which enables a rapid identification of the viruses. This is a very promising method for the identification and classification of viruses.

————————
Cucumber mosaic in greenhouse petunias. U.S.D.A. Plan Disease Rept. **22**(5) : 81–82, 1938.

Chona, B. L.
Scheme for research on mosaic and other diseases of sugar cane. Scient. Rpt. Imp. Inst. Agric. Res. (New Delhi) **1935–36**: 112–122, 1937.

Chonard, P., & Dufrénoy, J[ean]
Assais sur les pommes de terre par les maladies a virus en haute montagne. Bull. Soc. Nat. Acclim. (France) **85**(192) : 40–44, 1938.

Choudina, I. P.,
(The virus disease of tobacco plants in the U.S.S.R.) (Narkompishchenprom S.S.S.R.—Glavtabak. Vscsoiuzuyi Nanchni Issledovatelskii Institut Tabachnoi i Makhorochnoi Promyshleunosti im A. I. Mikoiana V (I.T.I.M.), Septor Zashchity Tabaka. Vykusk Krasnodar, No. **126**. 76 p., 1936.

Christoff, Alexander
Mosaikfleckigkeit Chlorose und Stippenfleckigkeit bei Atpfeln, Birmen und Quitten. (Mosaic spotting, chlorosis and bitterpit spotting in apples, pears and quinces.) Phytopath. Zeitschr. 8(3) : 285–296, 1936.

The author describes and compares in brief notes the different virus diseases of the mentioned fruits. Although the space devoted to each fruit is small his explanations are very comprehensive.

Ciccarone, A.,
Una virosi del Pomodoro. (Nota preliminare.) (A virus disease of tomato.) (Preliminary note.) Rev. Pat. Veg. **27** (3–4) : 73–77, 1937.

Perfection variety grown from English seed developed from leaf.

Clauss, G.
Anbauversuch mit start eisenfleckingen Kartoffelsastgut der Sorte "Sickingen". Tätigk,—Ber. Staatl. Landw. Vers.—Anst. Augustenberg f. **1933–34**, 76 p., 1935.

Clayton, E[dward] E[astman], Smith, H. H. & Foster, H. H.,
Mosaic resistance in *Nicotiana tabacum*. Phytopathology (Abstract) **28**(1) : 5, 1938.

Abstract of paper read before the American Phytopathological Society, December, 1937. Thirty-six strains collected in Colombia were resistant.

————————
Mosaic resistance in *Nicotiana tabacum* L. Phytopathology **28** (4) : 286–288, 1938.

A brief note giving results of recent work.

Clinch, Phyllis E. M. Loughnane, James B., & Murphy, Paul A[loysius]

A study of the aucuba or yellow mosaic of the potato. Roy. Dublin Soc. Sci. Proc. n.s. **21**(41): 431–448, 1936.

This is a study of aucuba mosaic of potato, tuber blotch virus which is isolated out of interveinal mosaic of potato and a latent virus in Dutch variety of Monocraft potato. These viruses attack several other plants and tuber blotch virus has been transmitted by *Myzus persicae*, but only in the presence of virus A. These viruses are similar in physical properties, including filterability, thermal death point and longevity *in vitro*. Tuber blotch and Monocrat viruses are identical and probably correspond to the viruses underlying pseudonetnecrosis, the aucuba virus being a distinct but related form and the calico virus is probably related as well. The authors propose to designate the tuber blotch virus as F. with Monocrat virus as a synonym and the aucuba mosaic as G. They classify the potato viruses in three groups as follows: (1) virus X of Smith, (2) virus F of Clinch, Lounghnane & Murphy and (3) virus Y of Smith.

Cobb, N. A.

Stigmonose. Agric. Gaz. New South Wales. **14**: 692, 1903.

At the time of this publication the disease was not considered by any investigator as due to a virus.

Cochran, L. C., & Hutchins, Lee M[ilo]

Peach-mosaic host-relationship studies in southern California. Phytopathology (Abstract) **27**(9): 954, 1937.

Abstract of paper read before the 21st Annual Meeting of the Pacific Division of the American Phytopathological Society. Mosaic has been found on apricot, almond, prune, plum and myrobolan plum. Some cross inoculations with buds have been made. "Identity of the viruses with peach mosaic, however, should not be regarded with more than strong suspicions until cross-inoculations have been completed."

————————, & Smith, Clayton O.

Asteroid spot, a new virosis of the peach. Phytopathology **28** (4): 278–281, 1938.

A description.

Cochran, W. G.

The statistical analysis of field counts of diseased plants. Journ. Roy. Statist. Soc. (Suppl.) **3**(1): 49–67, 1936.

Studies of spotted wilt of tomatoes which are correlated with studies of transmission by *Thrips tabacci*.

Cockerham, George, & McBain, Alan M.

Virus disease research. Scottish Soc. Res. in Plant Breeding, Ann. Rpt. pp. 13–17, 1936.

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Potato flowers and dissemination of potato viruses. Nature **140**: 1,100, 1937.

The author concludes that the tendency of varieties to flower or not flower has little effect on the transmission of potato virus diseases.

\-\-\-\-\-\-\-\-\-\-\-\-\-, **Ferguson, Hugh., & Lyoll, Charles A.**
Virus Disease Research. Scottish Soc. Res. in plant Breeding, Ann. Rpt. 1937. p. 14–17, 1938.

A report of progress. Potato viruses reduced yields as follows,—X virus (least effect), A + X complex, Y virus, Leaf roll (greatest). All viruses reduced sexual reproduction by reducing number of flower trusses.

Cole, J[ohn] R[ufus]
Bunch disease of pecans. Phytopathology (Abstract) **27**(2): 125, 1937.

A description of a disease which resembles some of the virus diseases. Cause not definitely known but it is transmitted by grafting.

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Bunch disease of pecans. Phytopathology **27**(5): 604–612, 1937.

This disease is distinct from the rosette disease of pecan. It resembles some of the virus diseases. It has been transmitted by grafting.

Coleman, Leslie C[arles]
Virus diseases of plants. Journ. Mysore Agric. & Expt. Union **10**(3): 125–132, 1929.

Cook, Harold T[hurston]
Mosaic-like trouble of elm in Virginia. Plant Disease Rept. **20** (14): 227–, 1936.

Cook, Melville T[hurston]
Insect transmission of virus diseases of plants. Sci. Month. **44** (2): 174–177, 1936.

A semi-popular review of the subject with special reference to the work in Japan on the rice dwarf.

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Descriptions of virus diseases of plants, criticisms and suggestions. Journ. Agric. Univ. Puerto Rico **20**(3): 689–690, 1936.

Suggestions and criticisms for authors of papers on these diseases.

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Phloem necrosis in the stripe disease of corn. Journ. Agric. Univ. Puerto Rico **20**(3): 685–688, 1936.

The results of a study of the histology of corn plants infected with this disease.

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Enfermedades nuevas o poco conocidas de la caña de azúcar en los Antillas. (New or little known sugar cane diseases in the Antilles.) Rev. Agric. Puerto Rico. (Suppl. 1, Mem. Assoc. Sugar. Cane Tech.) p. 5–13, 1936.

Short description of diseases of minor importance. Some of them appear to be due to viruses.

————————
Records of virus diseases of plants in Puerto Rico. Journ. Agric. Univ. Puerto Rico **20**(3): 681–684, 1936.

Records and notes on 17 virus or virus—like diseases.

————————
First supplement to the host index of virus diseases of plants. Journ. Agric. Univ. of Puerto Rico. **20**(3): 691–727, 1936.

A continuation of the host index published in the above Journal 19(3): 315–406, 1935. It contains 10 new families, more than 50 new genera and about 150 new species of host plants.

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First supplement of the index of vectors of virus diseases of plants. Journ. Agric. Univ. Puerto Rico **20**(3): 729–739, 1936.

Continuation of the index published in the above Journal 19(3): 407–420, 1935. It adds about 25 genera and more than 25 species to the original index.

————————
The witches' broom of *Tabebuia pallida* caused by a virus. Phytopathology (Abstract) **27**(2): 125, 1937.

This disease has been attributed to a fungus. It is due to a virus.

————————
Cucumber mosaic in Puerto Rico. Phytopathology (Abstract) **27**(2): 125, 1937.

The first severe outbreak in Puerto Rico during the past 13 years.

————————
Pioneers in the study of virus diseases of plants. Sci. Mon. **46**: 41–46, 1938.

The author arbitrarily places 1920 as the end of the pioneer period and selects eight workers as pioneers. They are Adolph Edward Mayer, Dmitri J. V. V. Iowanowski, Martinus Willem Beijerinck, Hendrick Marius Quanjer, Erwin F. Smith, Albert F. Woods, Harry A. Allard and James Johnson. Brief statements are made concerning the reasons for selecting them as the pioneers in this branch of plant pathology.

Coons, G[eorge] H[erbet], Stewart, Dewey, & Elcock, H. A.
Sugar-beet strains resistant to leaf spot and curly top. U. S. Dept. Agric. Yearbook **1931**: 493–496, 1931.

————————, **Kotila, J[ohn] E[rnest], & Stewart, Dewey**
Savoy a virus disease of beet transmitted by *Piesma cinera*. Phytopathology (Abstract) **27**(2) : 125, 1937.

A description of symptoms and some experiments. Is the same as the disease described by Arthur and Golden in 1892. Occurs in many central and western states.

————————
Improvement of the sugar beet. U.S.D.A. Yearbook **1936** : 625–656, 1937.

Contains a brief discussion on resistance to curly top.

Cooley, L[uster] M[anrina]
Sources of raspberry mosaic infections and how to get rid of them. Proc. New York State Hort. Soc. **80** : 273–277, 1935.

Semi-popular.

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Wild brambles in relation to spread of virus diseases in cultivated black raspberries. New York Agric. Expt. Sta. (Geneva) Bull. **665**, 5 p., 1936.

Wild red raspberries are numerous in western New York. They are usually with either green or yellow mosaic virus or with both. They support a large population of the *Amphorophora rubi* which is a vector. Any control must take into consideration the eradication of the wild red raspberry host. Other wild raspberries and black berries did not appear to be as important as the red raspberries. Leaf curl was rare but the vector *Aphis rubicola* common. The spread of this disease was slow. Streak viruses were rare.

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Wild bramble eradication. New York Agric. Expt. Sta. (Geneva) Bull. **674**, 32 p., 1936.

A discussion of methods of eradication.

————————
Retarded foliation in black raspberries and its relation to mosaic. New York Agric. Expt. Sta. (Geneva) Bull. **675**, 20 p., 1936.

The green mottle mosaic virus retards the development of the foliage. The yellow mosaic virus has much less influence.

————————
The control of raspberry mosaic. New York State Hort. Soc. Proc. **81** : 277–278, 1936.

Popular.

Costantin, Julien [Noel]
(Potatoes in highlands.) Compt. Rend. Acad. Sci. **181** : 633–636, 1925.

Actualités biologiques. Evolution de nos conceptions sur la dégénérescence et la symbiose (Biological notes. Evolution of our conception on degeneration and symbiosis.) Ann. Sci. Nat. X ser. Bot. (Paris) **15**(2):1–43, 1933.

In this article the author makes reference of Sereh disease of sugar cane.

Pathologie végétale. Exteriorisation des dégénérescenses pai l'action de l'altitude. (Plant Pathology. Exterioration of degeneration by the action of the altitude.) Compt. Rend. Hebd. Séanc. Acad. Agric. (France) **20**:414–419, 1934.

Crépin, C.
Quelques réflexions á propos de la pomme de terre. (Some observations in conection with the potato.) Compt. Rend. Acad. Agric. (France) **22**(11):437–440, 1936.

The author gives a review of our knowledge. The aphid vectors were the most important factors in the growing of healthy plants.

Cristinzio, M.
Un grave attacco dimosaico nella zucca. (A serious attack on pumpkin.) Riverche Osserv. e Divulg. Fitopat. Camp. ed Mezzog. R. Osserv. Reg. Fitapat. Portici. **6**:95–102, 1937.

Damm, R.
Abbau-und Viruskrankheiten der Kartoffeln. (Degenration and virus diseases of potatoes.) Mitt. Landwirtsch **51**(2):1116, 1936.

Dana, B[liss] F., & McWhorter, F[rank] P[aden]
An outbreak of curly top on pansy. Phytopathology **25**(9):894, 1935.

Occurrence of curly top in the Pacific coast in 1935. U.S.D.A. Plant Disease Rept. **20**(24):72–76, 1936.

Records of field studies.

Occurrence of curly top in the pacific Northwest in 1936. U.S.D.A. Plant Disease Rept. **21**(3):53–54, 1937.

Records of the occurrence of this disease in many localities and data of losses.

Curly top or western yellow blight of tomato. Oregon State Hort. Soc. An. Rpt. **28**(1936):72–74, 1937.

The curly top disease of vegetables in the Pacific Northwest. Oregon Agric. Expt. Sta. Circ. Inform. **180**, 5 p., 1938.

Occurrence of curly top in the Pacific Northwest in 1937. Plant Disease Rept. **22**(5): 82–84, 1938.

Records.

Darlington, C. D.
Reversion in black currants: a study of the chromosome complement. Journ. Pomol. & Hort. Sci. **6**: 242, 1927.

Darcy, C.
Les maladies de dégénérescence de la pomme de terre. (Degeneration diseases of the potato.) Jardinage **23**(198): 28–30, 1935.

Darrow, G. M., & Demaree, J. B.
Northern type of strawberry dwarf serious on the Chesapeake Peninsula. U.S.D.A. Plant Disease Rept. **23**(7): 109, 1938.

Davis, J[ohn] J[une]
Nature of disease producing viruses. Nature **124**: 267, 1929.

Davis, M. V., & Blair, P. S.
Virus diseases of cherries in British Colombia. Canadian Hort. (Fruit Ed.) **59**(9): 208, 1936.

Popular.

Decoux, L., & Roland, G.
Recherches effectuées en 1936 sur la jaunisse et la mosaique de la betterave (Research work on virus yellows and mosaic of the beet-root in 1936.) Publ. Inst. Belge Amel. Betterave **5**(5): 449–454, 1937.

------------, **Vanderwaeren, J., Roland, G. & Simon, M.**
Revue des travaux de l'Institut Belge pour l'Amelioration de la betterave de 1932 a 1936. (Review of work on the improvement of the beet during 1932 to 1936 at the Belgium Institute.) Publ. Inst. Belge. Amel. Betterave **6**(1): 4–35, 1938.

Deighton, F. C.
Preliminary list of fungi and diseases of plants in Sierra Leona. List of fungi collected in Sierra Leona. Bull. of Misc. Information. Roy. Bot. Gard. Kew **7**: 397–433, 1936.

This list contains mention of several virus diseases.

Demaree, Juan B., & Darrow, George M.,
Leaf variegation in strawberries not considered a virus disease. U.S.D.A. Plant Disease Rpt. **21**(22): 400–403. 1937.

A description of the disease and evidence to show that it is not due to a virus.

Denley, C. L.
Mosaic control on Godchaux properties. Sugar Bull. **15**(20): 3–5, 1937.

De Long, W. A.
Variation in the chief ash constituents of apples affected with blotchy cork. (= bitter pit) Plant Physiology **11**: 453–456, 1936.

Desai, S[hirishkent] V[rijray]
Scheme for research on mosaic and other diseases of sugar cane. Agric. Res. Inst. Pusa (India) Scient. Rpt. **1933–34**: 154–167, 1936.

Dickson, B[ertram] T[homas], Wright, H. D., Carne, H. R., & Noble, R[obert] J[ackson]
Filterable viruses. Australian & New Zealand Ass. Adv. Sci. **21**: 437–439, 1933.

Popular.

Diehl, R.
Les problémes actuels de l'amélioration et des champs d'experiences de pomme de terre. (Present problems of improvements and the experimental fields of potato.) Le Sélectionneur Versailles **5**(2): 81–89, 1936.

Varietal test of potatoes in regard to degeneration.

Dixon, H. H.
Are viruses organisms or autocatalysts? Nature, **139**(3508): 153, 1937.

A discussion of the work by Stanley, Bawden and others.

Dobroscky, Irene D[orothy]
Insect studies in relation to cranberry false blossom disease. Amer. Cranberry Grow. Ass. Proc. Ann. Meet. **58**: 6–7; 10–11, 1928.

Doidge, E. M.
Scaly bark (psorosis) of citrus trees. Journ. Dept. Agric. South Africa **12**(1): 61–67, 1926.

D' Oliveira, M. de L.
Aspectos actuales do problema dos virus filtraveis. (Present aspects of the problem of filterable viruses.) Rev. Agron. (Lisbon) **24**(1): 52–63, 1936.

Doerr, R.
Allgemeine merkmale der virusarten. (General characteristics of viruses.) Z. Hyg. Infekt. Kr., **118**(6): 738–747.

A lecture before the Second International Congress of Microbiology.

Doolittle, S[ears] P[olydore], & Alexander, L. J.
Injury to greenhouse tomatoes as a result of a combined infection with the viruses causing tomato and cucumber mosaic. Phytopathology **26**(9): 920–922, 1936.

Description of a disease caused by Johnson's tobacco virus 1 and Doolittle's cucumber virus 1.

————————, & Beecher, F. S.

Seed transmission of tomato mosaic following the planting of freshly extracted seeds. Phytopathology **27**(7) : 800–801, 1937.

This paper refers to tobacco virus 1. The authors report a low percentage of seed transmission when freshly extracted seeds are use. There was a smaller percentage in old seeds. "The present note seeks to emphasize the possibility of seed transmission of mosaic in breeding work, where, to produce several generations of plants in close succession, seed is planted soon after its extraction from the fruit. Where this is done there seems to be a definite danger of an appreciable amount of seed transmission of the virus."

Dorst, J[acobus] C[ornelius]

Transmission de la maladie de la mosaique par blessure ou par contact des plantes. (Transmission of mosaic disease through wounds or by contact of plants.) Rev. Bot. Appl. d'Agric. Trop. **11**: 264–265, 1931.

Transmission of potato mosaic.

Dounin, M. S.

A study of fungi and bacteria having virophoric and virocide properties. Summary Sci. Res. Inst. P. R., U.S.S.R. p. 509–510, 1936.

Dufrénoy, Jean

Étude cytologique des plantes affectées par des maladies a virus. (Cytological study of plants affected with virus diseases.) Ann. Epiph. **14**: 163–171, 1928.

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Changes induced in cells of sugar cane mosaic. Proc. Pacific Sci. Congr. 4th. Java, 1929. **4**: 25–27, 1930.

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Sur un virus des Renonculacées transmissible su *Nicotiana tabacum*. Compt. Rend Soc. Biol. Réunion Bordeaux **117**: 373–375, 1934.

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Les maladies á virus. (Virus diseases.) Défensa Sanitaire Végétaux. Compt. Rend. Trav. Congr., (Paris) **1934**: 24–26, 1935.

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Les maladies a virus. (Virus diseases.) Defense Sanitaire Végétaux Compt. Rend. Trav. Congr. (Paris) 1934, **1**: 207–210, 1935.

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L'immunité des plantes vis-vis des maladies virus. (The immunity of plants vis-a-vis of virus diseases.) Ann. Inst. Pasteur **54**: 461–512, 1935.

In this rather extensive work the author discusses his points of views in regard to plant immunization specially the effect of inoccu-lations.

Structure et métabolisme cellulaire. (Structural and *cellular* metabolism.) Arch. Anat. Mic. **31**(1) : 1–77, 1935.

Cytological studies of virus diseases of plants.

Le "spotted-wilt" (The spotted wilt). Ann. Epiphytes & Phyto. **3**(2) : 187–223, 1937.

General account of the disease known as spotted wilt; the author gives the different hosts subject to the symptoms of that form of mosaic. Gives also a list of viruses which cause local lesions.

--------------, & Bouget, J.
Études sur des maladies a virus de la pomme de terre. (Studies of virus *disease* of the potato.) Ann. Sci. Nat, Bot. **19**(10) : 181–202, 1937.

General discussion on the different types of virus diseases of potatoes. The authors give a brief description of symptoms in each case. They also discuss the effect of climate.

Duggar, B[enjamin] M[inge], & Hollander, Alexander
Inactivation of the virus of typical tobacco mosaic and of *Escherichia coli* in the shorter ultra-violet. Journ. Bact. (Abstract) **31**(1) : 52, 1936.

Dumon, A. G.
La propagation des maladies de dégénérescence en Belgique. (The propagation of degeneration diseases in Belgium.) Sattion D' Amélioration des Plantes (Héverle) Inst. Agron. Univ. Catholique de Louvain No. **4**, 20 p., 1931.

Popular account of five years observations on field work.

-------------, & Swartele, A.
Het ontaar-dingsvraagstuk bij Fragaria. (Le probleme de la dégénérescence chez le fraisier.) (The problem of strawberry degeneration.) Lanbou van de Univ. te Louven. voor owgepaste Genetica. pp. 1–10, 1937.

The serological method did not show in virus in degenerate strawberry plants.

The authors do not consider the method of value.

Dutt, N. L. Hussainy, S. A., & Krisbnaswani, M. K.
A note on the breeding of sugar cane varieties resistant to mosaic. Indian Acad. Sci. Proc. **3**(6) : 425–431, 1936.

The data indicates that resistance is correlated with the presence of bristles on the leaves.

Dykstra, T[heodore] P[eter]
Report on potato virus diseases in 1936. Amer. Potato Journ. **14**(4) : 117–124, 1937.

Popular.

Eckerson, S[ophia] H[emion], & Webb, R[obert] W[illiam]

The intracellular bodies associated with rosette disease and mosaic-like mottling of wheat. Journ. Agric. Res. **26**(12) : 605, 1923.

Edwards, E. T.

The witches' broom disease of lucerne. Australian & New Zealand Assoc. Adv. Sci. Rpt. **22**: 323–324, 1935.

The witches' broom disease of lucerne. New South Wales Dept. Agric. Sci. Bull. **52**, 31 p., 1936.

This is a report of the continuation of the studies by the author which have been reported in two previous papers. He discusses the symptoms, distribution and economic importance of his work. He also gives a detailed account of his own investigations. The disease has been transmitted by grafting.

Witches' broom of lucerne. A series disease in inland areas. Agric. Gaz. New South Wales **47**(8) : 424–426, 1936.

Popular account of the work reported in Res. Bull. 52.

Ehrke, G.

Die Eisenfleckigheit der Kartoffel. Forschungen u. Fortschritte **12**: 24–25, 1936.

Eide, C. J.

Plant viruses. Minnesota Hort. **65**(10) : 191–193, 1937.

Emmerez de Charmoy, D[onald d']

Die mosaikkrankheit des Tabaks auf Mauritius. (Tobacco mosaic disease in Mauritius.) Internat. Idw. Rundschan, p. 775, 1928. (Zeitschr. f. Pflanzenkrank. (Planzenpathologie) und Pflanzenset. **40** Band, heft 6, 1930.)

Mosaic of recent appearance.

Nouvelle contribution a l'étude du streak. (New contribution to the study of streak.) Rev. Agric. Ille. Reunion **39**: 193–202, 1934.

La lutte contre la mosaïque de la canne a sucre a la Reunion. (The fight against sugar cane mosaic in Reunion.) Revue Agr. Ille Reúnion **42**: 1–10, 1937.

Emon, J.

Une opinion sur la court-noué. (An opinion on "court noué".) Progr. Agric. & Vit. **105**(2) : 41–43, 1936.

Eriksson-Quensel, Inga-Britta, & Svedberg, The
Sedimentation and electrophoresis of the tobacco mosaic virus protein. Journ. Amer. Chem. Soc. **58**(10): 1863–1867, 1936.

The authors worked on tobacco virus protein furnished by Stanley. They found a considerable inhomogeneity with regard to molecular weight but said that it was not improbable that the virus protein might be homogenous with regard to molecular weight in its native state. The electrophoretic determinations showed the virus protein to be chemically well--defined and practically homogenous.

Evans, I[lltyd] B[uller] Pole
Bitter-pit of apple. South African Dept. Agric. Tech. Bull. **2**, 1911.

Pasture research and crop production. Annual Report of the Division of Plant Industry, Farming in South Africa, **10**(117): 548–560, 1935.

Mentions leaf curl and kromnek of tobacco (which is probably same as spotted wilt). Also scaly bark or psorosis.

Ewart, A. J.
Cause of bitter-pit. Proc. Roy. Soc. Victoria, Australia n.s. **30**: 15–20, 1917.

At the time of this publication the disease was not considered by any investigator as due to a virus.

Ewert, R.
Zum Abbau der Kartoffel. Beobachtungen über den abbau der Kartoffel unter besonderer Berücksichtigung des vergangenen Jahres. Deutsche Landw. Presse **62**: 41–42, 55–56, 1935.

Eyer, J. R.
Observations on the pathological history and phyto-chemistry of psyllid-yellows. Phytopathology **25**(9): 895, 1935.

Fawcett, G[eorge] L[orenzo]
El enrulamiento de las hojas de la tomatera. (The curling of the leaves of the tomato.) Rev. Ind. Agr. (Tucumán) **10**: 49–54, 1929.

El encrespamiento de las hojas de la remolacha y el insecto transmisor. (The curling of the leaves of the beet and the transmitting insect.) Rev. Ind. Agr. (Tucuman) **18**: 61–66, 1937.

Fawcett, H[oward] S[amuel]
Scaly bark, citrus scab, gumming of citrus, fungi on citrus whitefly. Florida Agric. Expt. Sta. Rpt. **1906–07**: 43–49, 1907.

Scaly bark of citrus. (A preliminary report.) Florida Agric. Expt. Sta. Bull. **98**: 73–78, 1909.

————————
Stem-end rot, gummosis, nail-rust, citrus scab, *Aegerita Webberi*, *Cephaoloporium lecanii*. Florida Agric. Expt. Sta. Ann. Rpt. **1909–10**: 45–65, 1910.

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Scaly bark or nail-rust of citrus. Florida Agric. Expt. Sta. Bull.. **106**, 41 p., 1911.

————————
New information on psorosis or scaly bark of citrus. Calif. Citrograph. **18**(12) : 326, 1933.

A new symptom indicates that the diseases may be due to a virus.

Feiginson, N.
(Determination of the crops susceptible to virus diseases, geographical distribution and injuriousness of virus diseases of plants.) Summ. Sci. Res. Work Inst. Pt. Prot., **1935**: 505–507, 1936.

Contains very valuable data on a number of virus diseases.

Ferguson Wood, E. J.
Some anatomical and cytological studies on fiji disease of sugarcane. Proc. Roy. Soc. Vict. N. S. **49**(2) : 308–313, 1937.

A very complete discussion.

Fernandes, D. S.
Vootlookinge mededeeling over de corzaak van de zeefvatenziekte (phloemnecrose) bij de Liberia koffie en hare bestrijding. (Preliminary note on the cause of the sieve tube disease) (Phloem-necrosis) of Liberian coffee and its control.) Meded. Landbouwproefstat. (Suriname) **2**, 12 pp., 1928.

Fielitz, F.
Los ultravirus en patologia vegetal. (Ultraviruses in plant pathology.) Agron. Assoc. Estud. Agron. (Montevideo) **6**: 23–33, 1935.

————————
Ensayo sobre "Crespadura de las papas" enfermedad a virus filtrante. (Test on leaf-roll of potatoes a filterable virus disease.) Rev. Assoc. Rural Uruguay **63**(4) : 23–28, 1936.

————————
Ensayo sobre "crespadura de las papas", enfermedad a "virus filtrante" (Test on leaf-roll of potato, disease due to a filterable virus.) Rev. Asoc. Rural Uruguay **63**(6) : 9–15, 1936.

————————, **& Bertelli, J. C.**
Enfermedad a ultravirus en las plantas "crespadura de las papas" primera comunicación 1934. (Virus disease of plants, potato leaf roll first note 1934.) Archivo Coc. Biol. Montevideo. **8**(1) : 46–57, 1937.

Filho, A. C.

As chlorosis de canna de açucar. (The chlorosis of sugar cane.) Brasil Azucareiro **6**(6) : 360–362, 1936.

Fife, J[ames] M[ilton] & Frampton, V. L.

The pH gradient extending from the phloem into the parenchyma of the sugar beet and its relation to the feeding behavior of *Eutettix tenellus*. Journ. Agric. Res. **53**(8) : 581–593, 1936.

When sugar beet seedlings are exposed to a high concentration of carbon dioxide preceding and during the period of inoculation of infection in the normal plants to that in the treated plants was 4.7:1. *Eutettix tenellus* feeds on the petioles of the plants treated with carbon dioxide it appears to lose its sense of direction in reaching the phloem. The ratio is 4.6:1. The insect prefers an alkaline food (pH 8.5) rather than a food with an acid reaction (pH 5.0). "The evidence indicates that leaf-hoppers feeding under normal conditions are probably guided to the phloem by pH gradient.

Föex, [Edmund] E[tienne]

Les maladies á virus. (Virus diseases.) Rev. Path. Comparée. 1925.

Au suject de la pomme de terre et des maladies dites de dégénérescence. (On the subject of the potato and the so-called degeneration diseases.) Compt. Rend. Acad. Agric. (France) **22**(14) : 573–576, 1936.

The author agrees for the most part with Crépin.

Folsom, D[onald], & Bonde, R[einer]

Some properties of potato rugose mosaic and its components. Journ. Agric. Res. **55**(10) : 765–783, 1937.

This disease is attributed to at least two viruses, the pure rugose mosaic or veinbanding virus and the latent mosaic virus.

------------, **et al.**

Net necrosis of potatoes. Maine Agric. Expt. St. Ext. Serv. Bull. **246**, 12 p., 1938.

A popular discussion of this disease with special reference to its relation to leaf roll.

Franke, H. M.

Untersuchungen über die Physiologie der pflanzlichen Virose. (Investigations on the new ideas of the physiology of plant viroses.) Biochem. Zeitschr. **293**(1–2) : 39–63, 1937.

Zur Physiologie der pflanzlichen Virose. (New ideas on the physiology of plant viroses.) Biochem. Zeitschr. **296**(1–2) : 149–152, 1937.

Freeman, Monroe Edward

Separation of one component of potato rugose mosaic by pH difference. Science n. s. **82**: 105, 1935.

Different pH values were used. Rugose mosaic of potato at pH 3.6 or less no symptoms. At pH 4.0 to 5.5 latent mosaic only. At pH 5.6–7.6 rugose mosaic symptoms. At pH 9.7 latent mosaic only was transmitted.

Freitag, J[ulius] H[erman]

Negative evidence on multiplication of curly top virus in the beet leafhopper, *Eutettix tenellus*. Hilgardia **10**(9): 305–342, 1936.

The author states that: "The results of the investigation indicate that the curly top virus does not multiply in the beet leafhopper. No evidence was found to support such a theory as has often been surmised on the basis of indirect evidence." The paper contains very interesting data.

————————, **& Severin, H[enry] H[erman] P[aul]**

Ornamental flowering plants experimentally infected with curly top. Hilgardia **10**(9): 263–298, 1936.

The disease was produced by experimental transmission in 92 species of ornamental plants in 73 genera and 33 families.

Friebe, P.

(The electrical measurement of the degree of "degeneration" of potato planting stock: A practical test with the new method of Hey and Wartenberg.) Pflanzenbau **9**(9): 351–355, 1933.

Friecklinger, H. W.

Eine neve Rubenkrankheit. (A new beet disease.) Die Umschan. **34**: 72–74, 1930.

A virus disease.

Fukushi, T[eikichi]

(An insect vector of the dwarf disease of rice plant.) Proc. Imp. Acad. Japan **13**(8): 328–331, 1937.

Gadd, C[aleb] H[erbert]

Phloem necrosis of tea. Inst. Ceylon, Ann. Rpt. **1936**: 27–28, 1937.

May be a virus disease. Causes a curling of the leaves.

Gaddis, B. M.

Eradication of citrus canker and control of phony peach and peach mosaic. Journ. Econ. Entom. **29**(5): 940–944, 1936.

The phony peach disease has been greatly reduced. The peach mosaic has spread with great rapidity.

————————
Control of phony peach disease. U.S.D.A. Plant Disease Rept. (Supplement) **96**: 36–41, 1937.

A brief history and discussion of methods of control. Also a statement as to present status and geographical distribution.

————————
Eradication of the peach mosaic disease. U.S.D.A. Plant Disease Rept. **96**: 45–46, 1937.

A brief review with statements as to progress on survey, eradication, present status and geographical distribution.

————————
Progress in peach mosaic eradication. California Dept. Agric. Spec. Pub. **155**: 50–54, 1938.

Gallis, P.,
L' Ugni blanc et le court-noué. (White "Ugni" and "court-noué".) Progr. Agric. Vitic. **107**(15): 346–347, 1937.

Observations supporting the work of Rous.

Galloway, L. D.
Report of the Imperial Mycologist. Scient. Rep. Imp. Inst. Agric. Res. (Pusa) **1934–35**: 121–140, 1936.

Contains a plan for research on mosaic of sugar cane.

Garbowski, L[udwik]
(Determination of the health of potato seed tubers by preliminary culture from the eyes.) Proc. Wudz. Chorn. Rosl. Panstw. Inst. Nank. Gosp. Wiejsk. Bydgoszczy. **15**: 31–41, 1936.

Experimental work demonstrated the value of the tuber-indexing method.

————————
Wplyw na rozwoj mosaiki smugowatej w doswiadczeniu z odmiana ziemniakow industria Modrowa. (Influence of soil on the development of streak mosaic in tests with the potato variety modrows Industrie.) Roczu. Neukrol., **41**(2): 387–391, 1937.

A test of diseased potatoes on sandy and on well manured soil. The plants on the sandy soil showed more pronounced symptoms of disease but the per centage of lose in yield was about the same.

————————
Próby przeszczepiania chorób wirusowych ziemniaków. (Tests on the transmission of virus diseases of potatoes.) Prece Wydzielu Chorob I Szkodników Roselin. Panstwowy Inst. Nankowy Gospoderstwa Wiejskiego. **16**: 5–39, 1937.

————————
Wplyw gleby na rozwój mosaiki smugowatej w doswiadczeniu z odmiana ziemniaków Industria Modrawa. (Influence of the soil in the development of "bigarrare" mosaic in the culture

of the variety of potato "Industria de Modrow".) Prace Wydsialu Chorób I Szkodnikow Roslin. Panstwowy Inst. Nankowy Gospoderstwa Wiajskiego **16**: 41–69, 1937.

Details of observations on the influence of soil on the behavior of potato mosaic of the type known as "bigarrure".

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Postepy badan nad chorobami wirusowymi roslin. Referat zbiorowy. (Progress on the studies concerning virus diseases of plants.) Prace Wydzialu chorób I Szkodnikow Roslin. Panstwowy Inst. Naukowy Gospodarstwa Wiejskiego. **16**: 127–173, 1937.

Gardner, M[ax] W[illiam,] Allard, Harry A[rdell,] & Clayton, E[dward] E[astman.]

Superior germ plasm in tobacco. U.S.D.A. Yearbook **1936**: 785–830, 1936.

Contains a short note on virus diseases. The Ambalema is the only variety tested that does not contract ordinary tobacco mosaic.

————————, **Tompkins, C[hristian] M[ilton,] & Thomas, H. Rex.**

Factors affecting the prevalence of the spotted wilt virus. Phytopathology (Abstract) **27**(2): 129, 1937.

Ghimsú, V.

Virusurile fitopatogene si virozele principalelor plante cultivate. Pagina Agrare Si Sociale 20 p., n. d.

Starting with a brief historical sketch the author, reviews the work of others and then discusses viruses of a great number of cultivated plants.

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Afectiunile patologici si inamici tutumulni din Romania in 1935. Bull. Cultiv. Ferment. Tutum. **24**(4): 410–418, 1935.

Notes on virus diseases of tobacco.

Giddings, N[ahum] J[ames]

A greenhouse method for testing resistance to curly top in sugar beets. Phytopathology **27**(7): 773–779, 1937.

The author describes a method, more rapid than the field method and gives some of the results.

Gigante, R[oberto]

Nota preliminare sulla "Necrosi del cuore" di patata. (Preliminary note on the heart necrosis of potato tubers.) Boll. R. Staz. Patol. Veg. **13**(1): 155–159, 1933.

A disease which is transmitted by the tuber.

————————
(Preliminary studies of the response of some Italian varieties of potatoes to the viruses.) Bol. R. Staz. Patol. Veg. (Rome), n.s. **15**(4) : 533–547, 1935.

A discussion of the reaction of four varieties of potatoes to the X and Y virus and to combinations of the same.

————————
Secondo contributo all conoscenza della necrosi del cuore dei tuberi di patata. (A second contribution to the knowledge of heart necrosis of potato tubers.) Boll. R. Staz. Paz. Veg. Roma, n.s. **15**(4) : 555–560, 1935.

Plants from diseased tubers grew as well as those healthy tubers but the disease appears to be hereditary.

————————
Una nueva virosi della rosa in Italia (A new viroses of the rose in Italy) Bol. R. Staz. Patol. Veg. Roma n.s. **16**(2) : 76–94, 1936.

Rome. Transmitted by a *Macrosiphum* aphid.

————————
Il mosaico del sedano (Celery mosaic). Boll. R. Staz. Patol. Veg. Roma, n.s. **16**(2) : 99–114, 1936.

Description of the disease and of experimental work in inoculation with aphids and from squash plants.

————————
Il mosaico della violaciocca. (Mosaic of the Stock (Gillflower).) Boll. R. Staz. Patol. Veg. Roma n.s. **16**(3) : 166–174, 1936.

Although brief, very comprehensive description of a virus disease of Stock flower (Gillflower) *Matthiola incana,* Histological, cytological and transmission studies were made.

————————
Una nuova malattia del pomodoro. (A new disease of tomato.) Bol. R. Staz. Pat. Veg. Rome n.s. **16**(3) : 183–199, 1936.

The author describes a disease of the tomato and the tomato plant ocurring in Sicily in 1935–36. Characterized by leaf variegation. After histological studies and observations the author concludes that the malady is due to a virus.

————————
La laciniatura da virosi delle foglie di pomodoro (The "fern leaf" virose of the tomato leaf) Bol. R. Staz. Pat. Veg. Rome n. s. **17**(1) : 87–119, 1937.

The author makes a very complete description of the disease. The cytological studies showed the presence of intracellular bodies which the author took for X bodies. Experimentally the disease was transmitted from plant to plant and from tomato plants to tobacco plants causing local lesions on the later. The author concludes by stating that the virus producing this type of disease in tomato is of a complex character.

————————
Ricerche istologiche sulle "Omeoplasis crestiform" (Enations) delle foglie di vite affette da rachitismo. (Histological investigations on "Omeophasia crestiformi" (Enations) of the vine leaf affected by "rachitism".) Bol. R. Stat. Patol. Veg. Rome. n. s. **17**(2) : 169–192, 1937.

The author reviews the work of others in regard to enation of several plants making comparison. Discusses thoroughly his histological studies. He concludes that transmission experiments will be the final sure proof that this disturbance may be due to a virus.

————————
Esperienze sulla trasmissibitá della "necrosi del cuore" dei tuberi di patata. (Experiences in the transmissibility of "heart necrosis" of the potato tuber.) Bol. R. Stat. Patl. Veg. Roma n. s. **17**(3) : 277–292, 1937.

Summarizing the author states that potato tuber "heart necrosis" is a hereditary disease which diminish the number of tubers produced in size and quantity and spoils its quality. He concludes that it is caused by a virus of the "Eisenfleckigkeit" type.

————————
Il mosaico della fava (*Vicia faba* L.) in Italia e comportamento di alcune leguminose di fronte ad esso. (The mosaic of the broad bean (*Viccia faba* L.) in Italy and the behavior of some leguminous that confront it.) Bol. R. Stat. Pat. Veg. **17**(4) : 497–530, 1937.

The author discusses the characters of *Vicia faba* L. mosaic disease, describes the disease, its histology and its transmission. He compares and discusses other leguminous virus diseases and concludes that the broad bean mosaic disease is not specific of the plant under study but that it presents characteristics of a complex virus.

Gokhale, V. P.

Preliminary observations on small-leaf disease in cotton. Indian Journ. Agric. Sci. **6**(2) : 475–480, 1936.

Golden, Katherine E.

Diseases of the sugar beet root. Proc. Ind. Acad. Sci. **1891** : 93–97, 1891.

The disease referred to in this paper and supposed to be due to bacteria was probably a virus disease recently described by Coons et al as "savoy".

Golding, F. D.

Cassava mosaic in Southern Nigeria. Nigeria Agric. Dept. Bull. **11** : 1–10, 1936.

The diseased plants yield 30 per cent less than the healthy plants.

Golding, M. I.

On the so-called masking of virus diseases. Compt. Rend. (Deplady) Acad. Sci. U.S.S.R. **15**(9) : 567–569, 1937.

Goodwin, W. & Salmon, E[rnest] S[tanley]
Infectious sterility in hop gardens in Czecho-Slovakia. Journ. Inst. Brew. n. s. **33**(4) : 209–210, 1936.

A summary based on description by Blattny and Vukolov.

Goss, R[obert] W[hitmore]
A review of the disease problems confronting the Nebraska growers of certified seed. Nebraska Potato Improvement Assoc. Ann. Rpt. **1935–36** : 6–14, 1936.

Contains records of virus diseases.

A review of the disease problems confronting the Nebraska growers of certified seed potatoes. Nebraska State Bd. Agric. Ann. Rpt. **1936** : 682–690, 1936.

Summary of potato disease records from certification inspection in Nebraska for the past five years. U.S.D.A. Plant Disease Rept. **20**(6) : 102–106, 1936.

Contains data on losses due to several virus diseases.

Gowen, John W[hitemore], & Price, William C[onway]
Inactivation of tobacco-mosaic virus by X-rays. Science **84** (2189) : 536–537, 1936.

The authors determined the type of curve in these experiments and say that:

"The type of curve obtained suggests that the absorption of a single unit of energy in a virus particle is sufficient to cause inactivation of the particle. This same type of curve can be used for the killing of many organisms."

The authors give a brief comparison of tobacco mosaic particles and genes, and say: "The fact that tobacco-mosaic virus is inactivated by radiant energy of the X rays and ultra-violet bands in a manner similar to that of genus suggested and alteration in the virus particles comparable to that which takes place in genes."

Graber, L. F., & Sprague, V. G.
Alfalfa yellows. Science **78**(2033) : 556, 1933.

Grainger, J[ohn]
An infectious chlorosis of the dock. Proc. Leeds Phil. & Lit. Soc. Sci. Sect. **1**(8) : 360, 1929.

------------, **& Angood, E.**
The insect transmission of raspberry mosaic. Proc. Leeds Phil. & Lit. Soc. Sci. Sect. **2**(4) : 183–184, 1931.

Some economic aspects of virus diseases in potatoes. The Naturalist, p. 151–153, 1933.

Low-temperature masking of tobacco mosaic symptoms. Nature **137**(3453): 31–32, 1936.

The symptoms were masked at 51° and 45°F. The optimum temperature for the plant growth was about 75°. The movement of the virus was greatest at 75° to 85°F.

Gram, Ernst.
Virusy domme hos kartoffler. Tidsskr. Landökon **2**(2): 61–81, 1935.

Grant, Theodore J., & Hartley, Carl.
A witches' broom on black locust and a similar disease on honey locust. U.S.D.A. Plant disease Rept. **22**(2): 28–31, 1938.

The authors give a large number of records and also describe a witches' broom on honey locust. It has not been definitely proven that these diseases are due to a virus. Cause not given. Resembles a virus disease.

Gratia, A[ndré]
Bacterophage et virus des plantes. (Bacterophage and virus of plants.) Bull. Acad. Méd. Belge. **5**(15): 208–225, 1935.

------------, **& Manil, P.**
Virus des plantes et herédite. (Plant viruses and heredity.) Compt. Rend. Soc. Biol. (Paris) **122**(22): 814–815, 1936.

The authors give their results of studies and give evidence against the hereditary theory of virus perpetuation.

------------, & ------------
Perte et récupération de la propriété "carrier" de virus X chez le pomme de terre. (Loss and recovery of the property of "carrier" of virus X in the potato.) Compt. Rend. Soc. Biol. (Paris) **123**(27): 325–326, 1936.

These studies indicate that seedlings from virus X inoculated with the virus were found after two weeks to possess a principle which was lost through sexual reproduction.

------------, & ------------
Pourquoi le virus de la mosaique du tabac et le virus X de la pomme de terre ne pressent-ils pas á la descendance par les graines? (Why are the tobacco mosaic and X potato viruses not transmitted to the progeny through the seed?) Compt. Rend. Soc. Biol. (Paris) **123**(29): 509–510, 1936.

Antisera studies show that the virus does not exist in the pollen and that it is attenuated in the floral organs.

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De l' ultracentrifugation des plantes. (On the ultracentrifugation of plants.) Compt. Rend. Soc. Biol. (Paris) **126**(27): 423–425, 1937.

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Ultracentrifugation et cristallization d' un mélange de virus de la mosaïque du tabac et de bacteriophage. (Ultracentrifugation and crystallization of virus of tobacco mosaic & bacteriophage.) Compt. Rend. Soc. Biol. (Paris) **126**(32): 903–906, 1937.

Gray, George W.
Where life begins: Search among the gene, the virus and the enzyme. Harpers' Magazine **174**: 279–289, 1937.

A part of this paper (pages 285–289) is devoted to a popular discussion of the work of Stanley with some reference to the work of others.

Green, D. E.
The virus of spotted wilt in Gloxinias. Gard. Chron. **2**(2488): 96, 159, 1934.

Popular.

Gregory, G. H.
Water-core in apples. Queensland Agric. Journ. **44**(6): 748–750, 1935.

Gulyás, Antal
Die Fasciation der Tabakblätten und die Mossikkrankheit. (Sports of tobacco leaf and the mosaic disease.) Jahrb. K. und Landw. Acad. Debrecen p. 129–136, 1928.

Die mermorierte Panaschierung der Tabakblätter und das Mosaik. (The marmoreal variegation of tobacco leaf and mosaic.) Keisérlet. Közlem., Budapest **31**: 261–273, 1928.

A magyar dohanyok virus-betegeegei. (On the virus disease of Hungarian tobacco.) Rep. Hung. Agri. Expt. Sta. **39**(1–3): 1–34, 1936.

A discussion of several well known virus diseases.

Gutermann, C[arl] E[dward] F[rederick]
The lily project. Month. Bull. Hort. Soc. of New York. **1936**: 3–7, 1937.

Popular. Some data on mosaic.

Hansen, Henning P.
Virussygdomme hos kartoffel. (Virus diseases of potato.) Ugeskrift for Landmaend. **39**(81): 610–613, 1936.

Brief popular descriptions of the most common potato diseases.

Spredningsbetingelser for kartoffelens virussydomme i Forhold til praktisk Kartoffel-fremavl. Reprint from Ugeskrift for Landmaend 4 p., 1937.

The writer accounts for the finding of X, Y, and leaf roll virus diseases in Denmark.

Studier over kartoffelviroses I (Studies on potato virosis in Denmark.) Saortryk of Tidsskrift for Planteavl 42. Bind Glydendalske Boghandel Nordisk Forlag 631–681, 1937.

A discussion of the potato virus diseases in Denmark and the viruses involved.

Studier over kartoffel-viroses in Danmark (Studies on potato virosis in Denmark). Tidsskr. Planteavl. **43**(4) : 631–681, 1938.

Hansford, Clifford] G[erald]
Anual Report of Mycologist 1934. Rpt. Dept. Agric. (Uganda) year **1934** (Part II) : 73–88, 1936.

Mentions three types of rosette of *Arachis hypogaea.* (1) Typical rosette. (2) mottling of the leaves and (3) yellows or a pronounced mosaic.

Harley, C[arl] P[ierce]
Water-core of apples. Washington State Hort. Ass. Proc. **1934**: 105–108, 1935.

Harrington, F[rank] M.
Tuber index work. Potato Ass. Amer. Proc. 1928, **15**: 332–338, 1929.

Harris, R. V.
Mosaic disease of the raspberry in Great Britain. I. Journ. Pomol. & Hort. Sci. **11**(3) : 237–255, 1933.

The author recognizes types A, B, and C of mosaic, Devon leaf curl and Devon chlorosis. The author reported on susceptibility of varieties and other observations.

Zanthosis-virus of strawberry. Canada Dept. Agric. Canadian Plant Disease Survey **1930**: 60, 1934.

------------, **& Grubb, N. H.**
Raspberry mosaic disease. East Malling Res. Sta. Ann. Rpt. **1934**: 62–63, 1935.

Virus diseases of strawberry. East Malling Res. Sta. Ann. Rpt. **1934**: 63, 1935.

Growing healthy raspberries; the control of diseases and pests. East Malling Res. Sta. Ann. Rpt. **1935**: 232–242, 1936.

Includes a discussion of mosaic and two nutritional disorders in relation to mosaic, leaf-scorch and effect of manuring on mosaic.

————————, **& Hildebrand, A. A.**
An investigation of strawberry virus disease in Ontario. Canadian Journ. Res. **C 15**: 252–280, 1937.

A discussion of experimental studies in Canada.

————————
Virus diseases in relation to strawberry cultivation in Great Britain. A synopsis of recent experiments at East Malling. Report on Mycology and Bacteriology of the year 1936. East Malling Res. Sta. Ann. Rpt. **1936–37**: 201–211, 1937.

A review containing historical notes, methods of determination of yellow edge and crinkle. Also notes on vectors and control. Crinkle is transmitted by *Capitophorus fragaefolii* Col. which the author believes be the same as *Myzus fragaefolii* Cockll.

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Studies in Strawberry virus diseases. III. Transmission experiments with crinkle, 1935. Report on Mycology and Bacteriology for the year 1936. East Malling Res. Sta. Ann. Rpt. **1936**: 212–221, 1937.

The author describes his experiments which lead to the opinion that yellow edge and crinkle are distinct diseases.

————————, **& Hildebrand, A. A.**
An investigation of strawberry virus disease in Ontario. Canadian Journ. Res. C. (Bot. Sci.) **15**(6): 252–280, 1937.

Yellow edge in southeastern England and in southern Ontario may be identical. It is not known that either of these diseases is the same as the xanthosis of California. Three Ontario varieties are symptomless carriers. Varieties of *F. chiloensis* which have proved to be symptomless carriers with high resistance may prove to be absolute. *F. virginiana* are highly susceptible. Some highly resistant varieties are not entirely resistant.

Harrison, A[rthur L.]
The pea mosaic situation in New York State in 1936. U.S.D.A. Plant Diesase Rept. **20**(16): 259–260, 1936.

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Varietal susceptibility of lima beans to mosaic. U.S.D.A. Plant Disease Rept. **20**(18): 291, 1936.

————————, **& Burkholder W[alter] H[agemeyer]**
Canning bean diseases in New York in 1936. U.S.D.A. Plant Disease Rept. **22**(8): 290, 1936.

A report on the prevalence of common bean mosaic and of a new dwarfiing disease.

Hartung, W. J.
Evasion of curly leaf disease or "blight", Farm Bureau Mon., Monterey County **6**(3): 13–16, 1924.

Popular.

Hartzell, Albert

A study of peach yellows and its insect vector. Cont. Boyce Thompson Inst. **7**: 183–207, 1935.

The author gives a brief history of the disease, its distribution, symptoms and studies on insect transmission. *Macropsis trimaculata* is the only insect known to transmit this virus. Forty seven other insects were tested.

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Incubation period of peach yellows in its insect vector. Contr. Boyce Thomp. Inst. **8**(2): 113–120, 1936.

The incubation period ranged from 10 to 26 days. All experiments were made with nymphs except in one case in which adults were used. In the case of the adult the time was 16 days.

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Movement of intracellular bodies associated with peach yellows. Contr. Boyce Thomp. Inst. **8**(5): 375–388, 1937.

The author reports the movement of these bodies by means of cinephotomicrography. Bodies similar in appearance were found in the salivary glands of living *Macropsis trimaculata* which had feed on yellows trees for one to three weeks. Bodies were not found in insects fed on healthy trees. There appears to be a parallel relationship in aster yellows and the insect vectors. There is a much greater cellular disturbance in diseased plants and insects than in corresponding tissues from healthy plants and insects. Movement was also observed in infected tissues that were crushed on a microscope slide. This does not appear to be a Brownian movement.

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Bionomics of the plum and peach leafhopper, *Macropsis trimaculata*. Contr. Boyce Thomp. Inst. **9**(2): 121–136, 1937.

A careful study of this insect which is the vector of peach yellows.

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Movement of intracellular bodies associated with peach yellows. Phytopathology (Abstract) **27**(2): 130, 1937.

Harvey, R[oney] B[eecher]

Blanching celery. Minnesota Agric. Expt. Sta. Bull. **222**, 20 p., 1925.

The author gives the results of diseased celery plants when blanched. He states. ''It is indicated that the blanching of some varieties is hastened by the infection of the plants by mosaic disease. Chlorotic varieties are more easily blanched than dark leafed plants.''

Heberdey, Rudolf R.

Entomological investigations on the spike disease of sandal (anthicidae.) Indian Forest Rec. **20**(6): 1–24, 1934.

A study of the insect fauna of the sandal.

Heierle, E.
Untersuchungen einers unter dem famen Rosts in der Schweiz stark verbreiteten Tabakkrankheit. Ber. Schweiz Bot. Ges. **47**: 363–368.

The name ''rost'' is used for wildfire, angular leaf spot and virus diseases.

Heinicke, A. J.
Seed content and position of fruit as influencing stippen. Proc. Amer. Soc. Hort. Sci. 1920; **17**: 225–232, 1921.

Heinze, K.
Zur frage der uebertragung der Kartoffelvirosen duch jassiden. Phytopath. Zeitschr. **10**(6): 606, 1937.

Hervé, J.
Au subjet de la panachure de nos Hibiscus et de la panachure infectieuse des malvacées. Considerations pratique sur la culture des Hibiscus. (Variegation of our *Hibiscus* and infections variegation of the *Malvaceae*. Practical considerations on the culture of Hibiscus.) Bull. Agric. Fort. de France. n. s. **5**(2): 137–141, 1936.

Herzberg, K.
Filtrierbares Virus als Krankheits erreger bei. Mensch Tier, und Pflanze. Chemiker Zeitsg. **60**: 824, 1936.

Hewitt, J. Lee, & Truax, H. E.
An unknown apple disease. Arkansas Agric. Expt. Sta. Bull. **112**: 481–491, 1912.

To vizualize a distinction between viruses and organisms. Phytopathology (Abstract) **25**: 892, 1935.

Hill, A. V.
Yellow dwarf of tobacco in Australia. I. Symptoms. Journ. Counc. Sci. & Ind. Res. Australia **10**(3): 228–230, 1937.

A description of a disease which appears to be caused by a virus.

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t Big bud of tobacco. Journ. Counc. Sci. & Ind. Res. Australia **10**(4): 309–312, 1937.

A description of this disease.

Hirayama, Shigekatsu, & Yuasa, A.
(Cytological study of tobacco mosaic, II.) Ann. Phytopath. Soc. (Japan) **6**(2): 119–128, 1936.

This is a continuation of a previous paper on this same subject. There were no irregularities in the reduction division and the tetrads were normal. Diseased plants 88.91 per cent apparently normal pollen grains, while healthy produced 83.34 per cent. The degeneration appears

to develop after tetrad formation. A high percentage of seed crosses between diseased and healthy plants failed to germinate. Inoculation with boiled juice from diseased plants does not cause X bodies. Healthy plants placed in 0.05 per cent of ammonium molybdate wilted in 3 days and produced bodies resembling X-bodies.

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(On the germination of pollen obtained from mosaic tobacco plants.) Proc. Imp. Acad. Tokyo, **12**(7) : 203–204, 1936.

This work was suggested by Kostoff's reports. The author tested a large number of pollen grains. Sterile pollen was found in both healthy and diseased plants. Comparing the degree of the germination of apparently normal pollen between healthy and diseased plants, the average percentage of the germinated pollen is rather higher in the diseased plants than in the healthy ones. The writer observed the X or inclusion bodies in the pollen of the diseased plants.

____________, **& Yuasa, A.**

(Cytological study of tobacco mosaic, I.) Ann. Phytopath. Soc. (Japan) **5**(3) : 197–205, 1936.

The study was made on *Nicotiana tobacum* var. Hatano. The authors found X-bodies in all leaf tissues, in stems with hairs, in roots except in root hairs, root caps and calyptrogens and in the various parts of the flowers. However, they were rare in microsporogenous cells, pollen mother cells, pollen and pollen tubes. Striated materials, raphids, crystalline plates and amorphous bodies were found in all tissues contain X-bodies. The X-bodies and all other types of bodies appear to be derived from the cytoplasm.

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Occurrence of inclusion bodies in the guard cells of the stomata of mosaic-tobacco plants. Ann. Phytopath. Soc. (Japan) **6**(4) : 305–306, 1937.

The authors report the finding of inclusion bodies in guard cells of stomata. These results are contradictory to the results obtained by Sheffield.

Ho, William T. H., & Li, L. Y.

Preliminary notes on the virus diseases of some economic plants in Kwangting province. Lingnan Sci. Journ. **15**(1) : 67–78, 1936.

A report on virus diseases of *Capsicum* sp., *Carica papaya, Crotalaria saltiana, Ficus carica, Lycopersicon esculentum, Morus alba, Nicotiana tabacum, Phaseolus vulgaris, Solanum melongena, S. tuberosum, Saccharum officinarum and Zea mays* (sweet).

Hoggan, Isme A[ldyth], & Johnson, James.

Behavior of the ordinary tobacco mosaic in the soil. Journ. Agric. Res. **52**(4) : 271–294, 1936.

The authors made greenhouse and laboratory experiments with tobacco virus No. 1. The virus leached readily from decaying plants

into the soil. The degree of water saturation of the soil above a low minimum, and the range of hydrogen-ion concentration occuring naturally in soils, did not appear to affect the inactivation of the virus. Aeration evidently inactivated both directly and through its influence on microbial activity, but it separated relatively slowly. "Soil temperatures between 5° and 30°C. did appreciably affect the rate of inactivation of virus extract in the soil. At 40°C., inactivation was definitely greater. Freezing the soil, however, caused rapid inactivation of virus extract in the soil . . . . Neither freezing not desiccation caused any appreciable inactivation of virus present in undecayed plant tissues in moist soil."

Holmes, Francis O[liver]

Comparison of derivatives from distinct strains of tobacco-mosaic virus. Phytopathology **26**(9): 896–904, 1936.

The author worked with two strains, masked and distorting. Other derivatives were derived from these strains. A symptomless strain may give rise to derivatives causing severe symptoms. A symptomless strain may be introduced into a country and then give rise to severe derivatives. The author gives suggestions for detection of symptomless strains.

Interspecific transfer of a gene governing type of response to tobacco-mosaic infection. Phytopathology **26**(10): 1007–1014, 1936.

The author gives the following summary:

"A necrotic type of response to infection with tobacco-mosaic virus was introduced into the species *Nicotiana paniculata*. This was accomplished by the transferring a dominant gene N(necrosis) from *N. rustica*, through repeated back crosses of the hybrid *N. paniculata* X *N. rustica* using *N. paniculata* pollen, but retaining in each generation only individuals responding to inocculation by production of necrotic lesions. The necrotic-type variety of *N. paniculata* thus produced was self fertile and, in appearance, resembled the ordinary mottling-type *N. paniculata*. In its response to infection, however, it was essentially like *N. rustica*, dying from systemic necrosis if infected when young, localizing virus if infected when old."

"A dominant gene D(unmodified necrosis), not found in *Nicotiana rustica*, was observed in the newly derived necrotic-type *N. paniculata* plants. It was found to segregate independently with respect to the gene N.(necrosis). In the presence of N, the gene D allowed necrotic primary lesions to appear promptly, and prevented extensive yellowing of surrounding tissue."

Hereditary factors affecting tobacco-mosaic disease in solanaceous plants. Phytopathology (Abstract) **27**(2): 131, 1937.

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Genes affecting response of *Nicotiana tabacum* hybrids to tobacco-mosaic virus. Science **85**(2195) : 104–105, 1937.

The author gives the results of his studies on hybridization. The author believes that the virus would be unable to survive in plants containing certain genes and that it might disappear or be reduced by the elimination of the reservoir in the host plant.

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Inheritance of resistance to tobacco-mosaic disease in the pepper. Phytopathology **27**(5) : 637–642, 1937.

The author reports four types of the disease produced by infection of *Capsicum frutescens* with tobacco mosaic virus I (distorting strain) and that they are controlled by three genes.

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Taxonomic relationships of plants susceptible to infection by tobacco-mosaic virus. Phytopathology **28**(1) : 58–66, 1938.

This is a paper on plants susceptible to tobacco virus I. A total of 46 species in 30 genera and 16 families were found susceptible.

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Strains of tobacco resistant to tobacco mosaic. Phytopathology (Abstract) **28**(3) : 9, 1938.

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Inheritance of resistance to tobacco-mosaic disease in *Browallia*. Phytopathology **28**(5) : 363–369, 1938.

When identical plants of *Browallia speciosa* var. *major* were inoculated some of them developed systematic and some local symptoms. The necrotic-type plants were found to possess a dominant gene N.

Honing, J. A.

Een steriele dwergvorm van Deli-tabak, ontstaan als bastaard. A sterile dwarf form of Deli-tobacco originated as a hybrid. Deli Proefs., Medan, Sumatra. Bull. **10**, 24 p., 1917.

In the results obtained in his studies he made observations in relation to ''kroepoek'' disease relating them to the work of others.

Hope, C[laude King], C[halmers] J[ackson], & Parker O[rlan]

The effect of crazy top disorder on cotton plants and its control by irrigation management. U. S. Dept. Agric. Tech. Bull. **515**, 44 p., 1936.

A history, description and other data on this disease. A discussion of its economic importance and reaction to water supply.

Hopkins, J. C. F.

Seasonal notes on tobacco disease. 2. Mosaic. Rhodesia Agric. Journ. **28**(12) : 1095–1100, 1931.

Seasonal notes on tobacco diseases. 7–9. Rhodesia Agric. Journ. **32**(2): 108–113, 1935.

Part 7 refers to mosaic.

Horning, G.
Vergleichende Untersuchung verschiedener Methoden zur bestimmung des Abbau-grades bei Pflanzkartoffeln. (Comparative study of various methods for the determination of the degree of degeneration of potato seed tubers.) Pflanzenbau **13**(6): 209–234, 1936.

A report of comparative tests of the infection seed tubers of potatoes infected with virus diseases. A very low correlation was established.

Horsfall, J[ames G.]
A study of meadow-crop diseases in New York. Cornell Univ. Memoir **130**, 1930.

Contains some data on red clover mosaic.

------------, & Burkholder, W[alter] H[agemeyer], & Reinking, Otto A[ugust]
Diseases of green refugees beans in New York in 1937. U.S.D.A. Plant Disease Rept. **21**(17): 318–319, 1937.

A short paper devoted almost entirely to mosaic of *Phaseolus vulgaris* (green refugee). The types produced by Pierce and Walker and the Idaho refugee were practically immune to ordinary mosaic. A new disease designated as "one sided mosaic" was reported. This had been mentioned in 1936 by both Harrison and Burkholder. The authors give a description of the disease.

Hudson A. W., & Woodcock, J. W.
Locality in relation to seed potato production. Experiments on the effect of place of growing on yield and incidence of virus in potatoes. New Zealand Journ. Agric. **50**(2): 98–106, 1935.

Very comprehensive discussion of the results of their tests and observations.

Hurt, R. H.
The phony peach and other peach diseases in Virginia. Virginia State Hort. Soc. Rpt. **38**: 64, 69, 1933.

Hurst, R. R.
Resistance studies of Irish cobbler and Green mountain strains for late blight and virus diseases. Canada, Progress Rpt., Dominion Botanist, **1931–34**: 69–70, 1935.

Hus, P.
Stippigheid. De Nieuwe Veldbode **3**(9): 7–9, 1935.

Hutchins, L[ee] M[ilo]
Phony peach, a new and dangerous peach disease. Proc. Maryland State Hort. Soc. **34**: 43–51, 1932.

Peach mosaic. A new virus disease. Science **76**: 123, 1932.

A description of a new diseases.

The peach mosaic disease. California Dept. Agric. Selec. Pub. No. **145**: 60–61, 1937. .

-------------, **& Bodine, E. W., & Thornberry, H. H.**
Peach mosaic, its identification and control. U.S.D.A. Circ. **427**, 48 p., 1937.

A very excellent publication which gives a very thorough discussion of our knowledge of this disease up to this time. It is well illustrated.

Hutchinson, C. B.
Mottle leaf of citrus: Other diseases of citrus. California Agric. Expt. Sta. Rpt. **1932–34**: 59, 1934.

Mention of scaly bark or psorosis.

Imle, E. P., & Samson R[ayburn] W[alter]
Studies on a ring-spot type of virus of tomato. Phytopathology (Abstract) **27**(2): 132, 1937.

Ingram, J. W., & Summers, E. M.
Insects that carry mosaic disease of sugar cane. Sugar Bulletin **16**(6): 4–7, 1937.

The author refers to the three known carriers of this virus. *Aphis maidis, Hysteroneura setariae* and *Toxoptera graminum.* Also to other insects that may be carriers. Although *H. setariae* is not as efficient as *A. maidis,* it occurs in much greater numbers. The paper also refers to host plants and states that in studying insect transmission of mosaic it was considered that the amount of spread caused by insects is in proportion to the number of carriers present, and to the kind and number of alternate host plants in and around the field.''

Ivanic, M.
Ispitivanja etiologije nolesti mozaika u nekih fanerogamih biljaka (Untersuchungen über die altiologi der mosaik-krankheiten bei einighen phaneorogamen pflanzen.) Archiv. Monst. Poljopr. Smotra Mauch. Poljopr. Rad. (Yugoslavia) **1**(1): 107–133, 1934.

Jacob, J.
Tulip notes; suggestions about rectifications and arrangment. Garden (London) **82**: 304, 1918.

Jahnel, H.
Wuchsstoffauntersuchungen au Abbaukrankken Kartoffeln. (Auxin investigations on degenerate potatoes.) Phytopath. Zeits. **109**(1): 113–117, 1937.

Jamalainen, E. A.

Herneen sementen sisainen turmeltuminen. (Internal necrosis of pea seeds.) Valtion Maatalouskoeto iminnan Julkaisuja No. 79. (Agric. Expt. Sta. Activities of Finland No. 79.)

This disease is not due to bacteria or fungi. It shows some symptoms of a virus.

Boorin vaikutus knoppatandin ssüntymisseen omenissa. (The effect of boron on the occurrence of the cork disease in apples.) Valtion Maatalonskoeto iminnan Julkaisuja No. 89, (Agric. Expt. Sta. Bull. 89 of Finland.)

We have included this paper because some workers believe this disease is due to a virus. Most of the trees treated with boron were free from the disease.

Janson, A.

Stippe der Kernobstfrüche. Gardenflora 78: 241–242, 1929.

Jensen, James H[erbert]

Studies on representative strains of tobacco-mosaic virus. Phytopathology 27(1) : 69–83, 1937.

The author reports 55 strains of tobacco mosaic virus and describes 12 of them. They vary greatly in severity. Some of the strains were tested for reactions to heat and withstood a temperature of 80°C for 10 minutes.

Johnson E[dward] M[arshall] & Valleau W[illiam] D[ornay]

Susceptibility of tobacco plants visibly affected with mild tobacco mosaic to other strains of the virus. Kentucky Agric. Expt. Sta. Res. Bull. 360: 192–201, 1935.

The authors give the results of a series of experiments and say,—"The tests seem to prove that if a tobacco leaf inoculated with a second strain of a virus is unoccupied or partly occupied by the first strain, so that the second may multiply, the second virus will eventually be transported to the growing point where it will have an opportunity for multiplication equal to that of the first strain. The growing point of a tobacco plant appears to be entirely unprotected by one strain of a tobacco mosaic virus against another strain if the latter has sufficient uninvaded tissue in which to multiply and from which it may be transported to the growing point. Protection is afforded individual groups of cells, perhaps, but the plant as a whole does not develop immunity."

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The ring symptoms of the virus diseases of plants. Kentucky Agric. Expt. Stat. Res. Bull. 361: 239–263, 1935.

The extensive studies recorded in the paper are summarized as follows:

"Chlorotic or necrotic rings may be present as the only definite symptom or as an accompanying symptom in plants affected with various virus diseases. Rings may be present as local symptoms on inoculated leaves or as transitory or permanent symptoms in un-inoculated, completely or partially invaded tissue."

"The following tobacco viruses capable of producing rings in tobacco are discussed: Ring tobacco mosaic (2 strains), yellow and white mosaic, cucumber mosaics, etch viruses, viruses from *Delphinium* sp. *Plantago major,* and *Mertensia virginica* (possibly cucumber mosaic), and two unidentified."

"It is suggested that the ring symptom is not diagnostic for any specific virus disease because similar rings may occur in plants, especially tobacco, affected with such unlike viruses as tobacco ring spot, healthy potato, etch, tobacco mosaics, cucumber mosaics, and others. Usually other symptoms accompany the rings, which make classification possible, but sometimes property and host-range studies may be necessary for more exact classification."

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Mosaic from tobacco one to fifty-two years old. Kentucky Agric. Expt. Sta. Res. Bull. **361**: 264–271, 1935.

The authors summarize this paper as follows,—

"Turkish tobacco plants never touched by hands were inoculated with decoctions made from dried tobacco material 1 to 52 years old. Forty-one ground samples 24 to 39 years old were used to inoculate 241 tobacco plants of which 45 plants, representing 17 samples, developed mosaic. At least 5 different strains of mosaic, recognizable by different degrees of severity of symptoms, were produced from the Chemistry Department samples."

"Seventy-six samples, 1 to 15 years old, known to contain mosaic when collected, were used as inoculum for 84 tobacco plants of which 79 developed mosaic. There was no evident loss in infectivity of the mosaic virus in dried tobacco 7 years old. After 8 years there seemed to be gradual decrease in the concentration of the virus. At least 12 strains of the mosaic virus were tested and all survived in dried tobacco."

"Dried leaves from tobacco grown in 1882, the year Adolf Mayer published the first description of tobacco mosaic, were tested for tobacco mosaic virus. Of 30 plants inocculated with this materials, 18 developed mosaic. Two strains, a yellow, and a green distorting type, appeared."

Johnson, F[olke], & Jones, L[eon] K[ilby]

Two mosaic diseases of pears in Washington. Journ. Agric. Res. **54**(8): 629–638, 1937.

The authors report two virus diseases; (1) enation mosaic and (2) severe mosaic. They are rarely transmitted in the seed. The latter has a wide range of hosts and the former a much more limited range. The viruses are quite different.

Johnson, H[oward] W., & Lefebyre, C. L.
Crotalaria mosaic. Phytopathology (Abstract) **28**(1) : 10, 1938.

Johnson, James, & Hoggan, Ismé A[ldyth]
The inactivation of the ordinary tobacco-mosaic virus by micro-organisms. Phytopathology **27**(10) : 1014–1027, 1937.

Tobacco virus I is inactivated or occasionally attenuated by a number of bacteria and fungi. The fungi are more effective than the bacteria.

An acquired immunity to the tobacco streak disease. Trans. Wisconsin Acad. Sci. **30** : 27–34, 1937.

Plants that are naturally infected show signs of recovery. Eight-hundred plants inoculated in the green house have shown similar character; 130 of these plants were inoculated a second time but did not develop the diseases. Six other viruses did not yield any significant protection against the streak virus. The streak virus did not give protection against these six viruses.

Factors relating to the control of ordinary tobacco mosaic. Journ. Agric. Res. **54**(4) : 239–273, 1937.

The author used tobacco virus I. The virus survives in fairly high concentration in cigar and cigarretes but very slight in other commercial tobaccos. Virus in refuse may be inactivated under weather conditions in 5 or 6 months. It will survive in roots of the proceeding crop.

Jones, L[eon] K[ilby]
The mosaic disease of beets. Washington Agric. Expt. Sta. Bull. **250**, 16 p., 1931.

------------, **& Vincent, C[hester] L[eon]**
The susceptibility of potatoes to the vein-banding virus. Journ. Agric. Res. **55**(1) : 69–79, 1937.

This virus spreads rapidly. Crosses show that katahdin was the only variety which transmitted resistance to seedlings. Some varieties were more resistant than others. Some varieties carrying a latent virus showed symptoms of rugose mosaic when infected with vein-banding virus.

Crinkle and mosaic of Geranium. Phytopathology (Abstract) **28**(1) : 11, 1938.

------------, **& Burk, Earl F.**
The resistance of Katahdin potato seedlings to infection by the veinbanding virus and the tobacco mosaic virus. Phytopathology (Abstract) **28**(1) : 11, 1938.

Kadow, K[enneth] J[ohn,] & Anderson, H[arry] W[arren]
Brittle root of horse-radish in Illinois. U.S.D.A. Plant Disease Rept. **22**(18) : 288, 1936.

This disease has been known for several years. It is identical with curly top of beet on horae radish as described by Severin. The leafhopper (*Eutettix tenellus*) has not been reported from Illinois but other leaf hoppers are abundant.

Kaho, K.
Das Verhatten der Eiweisstoffe gesunder und abbaukranker Kartoffelknollen gegen Salze. Acta Comment. Univ. Tactuensis **A29** : 1–32, 1935.

Kameras, A. T.
(Neueste methoden zur laboratoriellen Bestimmung des Abbanes der Kartoffel an den Knolle.) Trudy Prikl. Bot. Pr. Ser. A. **9** : 63–76, 1934.

————————, **& Anikieff, A. M**
(Investigation of degeneration in the potato by Bechhold and Erbe's method.) Bull. Appl. Bot. Select, 1937. Ser. **2**(11) : 201–214, 1937.

Results of year's tests using B. & E. copper strip method. The method is not altogether accurate.

Katsura, Saburo
The stunt disease of Japanese rice, the first plant virosis shown to be transmitted by an insect vector. Phytopathology **26**(9) : 887–895, 1936.

A very complete history of the studies by several Japanese plant pathologists.

Kaufmann, O.
Eine gefährliche Viruskrankheit an Rübsen, raps und Kohlrüben. (A dangerous virus disease of rape, colza and kohlrabi.) Arb. Biol. Reichsanst. Land-u-Forstw. (Berlin) **21**(4) : 605–623, 1936.

A descriptive of this disease which is transmitted by *Lygus pratensis.*

Kausche, G. A.
Zur Frage der Beziehungen zwischen Virusinfekt und Stoffwechselphysiologie bei pflanzenlichen Virosen. (A contribution to the question of the relationship between virus infection and metabolic physiology in plant viroses.) Biochem. Zeitschr. **294** (5–6) : 365–371, 1937.

Kawamura, T.
(The mosaic disease of lily and the effect of deficiencies of potassium on the same host.) Journ. Plant Prot. **22** : 713–718, 771–779, 848–855, 1935.

The author describes three types of virus diseases,—(*a*) crooked neck, (*b*) rosette and (*c*) pimple leaf.

So-called virus diseases of lily in relation to hosts. Ann. Phyto. Soc. Japan **7**(3 & 4) : 163–172, 1937.

The author describes three types of virus diseases,—(*a*) crooked neck, (*b*) rosette and (*c*) pimple leaf.

Khudyne, I. P.
(Virus diseases of tobacco in U.S.S.R.) The A. I. Mikoyan Pan-Soviet Sci. Inst. Tob. and Indian Tob. Ind. V.I.T.I.M.). Krasnoder. Publ. **130**, 79 pp., 1936.

A review of tobacco virus diseases.

Kidd, F.
The bitter-pit problem. Low Temperature Res. Sta. (Unpublished Memoir) Cambridge, 1934.

Klapp, E.
Kartoffelabbau und Viruskrankheiten. (Potato degeneration and virus diseases.) Mitt. f. d. Landwirtsch. **49**: 523, 1934.

------------, et al.
Okologie und "Abbau" der Kartoffel. Beziehungen zwischen Ertragshöhe. Nachbaustufen, Krankheitsbefall und praktischem Pflanzewert. Pflanzenbau **11**(6) : 383–395, 1935.

Abbau und Abbaubekämfung im Pflanzkartoffelbau. (Degeneration and degeneration control in seed potato cultivation.) Mitt. Landw., (Berlin) **51**(32) : 692–694, 1936.

A discussion and recommendations.

Kartoffelabbau. (Running out "of potatoes") Forschungsdienst **1**(1) : 33–88, 1936.

A review of the subject with 38 references to literature.

Vordringliche Forschungsziele bei der Bekämfung des Kartoffelabbaus. (Urgent aims of research in the control of potato degeneration.) Forschungsdienst **3**(1) : 10–11, 1937.

The author suggests lines of research.

Klebahn, H[enrich]
Versuche über das Wesen der Mosaikkrankheit des Tabaks und über einige andere Viruskrankheiten. (Experiments on the nature of the mosaic disease of tobacco and on some other virus diseases.) Phytopath. Zeitschr. **9**(4) : 357–370, 1936.

I. Das virus des tabakmosaiks bei gegenwart starker gifte wirksam. II. Zur über-tragbarkeit der abutilon-chlorose. III. Weitere versuche über infektion der anemonen mit alloiophyllis. IV. Eine mosaikkrankheit der gurken. The virus was not destroyed by certain chemicals that destroyed bacteria. Therefore, the author believes that the virus is inanimate.

Klemm, M. J.
(Die Eisenfleckigkeit der Kartoffeln.) Ostpr. Landw.-Zeitg. **12** (7) : 3–5, 1935.

Klump, W.
Methodische Untersuchungen zur Feststellung des abbaugrades der Kartoffel. Diss. Bonn. 40 p., 1935.

Kobus, J[acob] D[erk]
Meded van het Proefstation voor de Java Sulkerindustrie **12** : 320-340, 1907.

Reduction of yield of sugar cane and sugar content by mosaic.

Vergelykende proeven omtrent gelestrepenziekte. Meded van het Proefstation voor de Java-Suikerindustrie **12** : 319–342, 1908.

Koch, G[ustav]
Zur Frage der Ursache des Kartoffelabbaues. D. Kartoffelbau **20** : 37–38, 1936.

Kohler, E[rich]
Der virusnadweis und kartoffeln. Biol. Reichs. Landw.-u. Forstw. 53, 1933.

Kartoffelabbau und Viruskrankheiten. (Potato degeneration and virus diseases.) Mitt. f. Landw. 12, 1934.

Viruskrankheiten der Kartoffel. (Virus diseases of potato.) Phytopath. Zeitschr, **7** : 1–131, 1934.

Der Nachweis von Virusinfektionen am Kartoffelpflanzgut mit der Stecklingsprobe. (The detection of virus infections in seed potatoes by testing the sprouted eyes.) Züchter **7**(3) : 62–65, 1935.

Erfahrungen veim feldmässigen Abbau von künstlich blattrollinfizierten, Kartoffeln (Sorte Kl.—sp. Wohltmann). (Undersuchuger über die Viruskrankreien der Kartoffel. V. Mitteilung.) (Experimental observations on the degeneration under field conditions of potatoes (Kl.—Sp. Wohltmann variety) artificially infected by leaf roll. (Investigations on the virus diseases of potato., Note V.) Arb. Biol. Reichsanst. Landu-u. Forstw. (Berlin) **21**(4) : 517–529, 1935.

Der Virusnachweis an Kartoffeln. Eine Anleitung für Züchter und Kartoffelbegutachter. (The detection of virus in potatoes. A manual for breeders and potato surveyers.) Mitt. Biol. Anst. (Reichsanst.) Berlin **53**, 9 pp., 1936.

The character of this paper is indicated by the title.

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Studien über den Verlauf des Kartoffelabbaus auf dem Dahlemer Versuchsfeld der Biologischen Reichsanstalt. (Studies on the course of potato degeneration on the Dahlem experimental plot of the National Biological Institute.) Landw. Jahrbüch **83**: 589–868, 1936.

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Untersuchungen über de Lupinenbräune. Nachrichtenbl. Deutsch. Pflanzenschutzd. **15**(2): 90–91, 1937.

Account of virus disease on Lupin.

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Neueve Vorstellungen von der Natur des pflanzenpathogenen Virus. Sammelreferat. (Recent conceptions of the nature of the plant-pathogenic virus. A symposium.) Zeitschr. Bot. **81**(12): 559–571, 1937.

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Weitere Untersuhcungen über das Virus der Lupinenbräune. (Further studies on the Lupin browning virus.) Z. Pflan. Krankl. **97**(2): 87–97, 1937.

This virus is the same as Ainsworth's yellow mottle mosaic of cucumber, Johnson's cucumber virus I, and spinach virus. It becomes attenuated in tobacco but can be revived in cucumber.

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Versuche über Pfropfung und Akronekrose bei Kartoffeln. Vorläufige Mitteilung. (Experiments on grafting and acronecrosis in potatoes. Preliminary note.) Angew Bot., **19**(2): 158–160, 1937.

The author grafted virus free scions on potatoes carrying virus X and obtained mild symptoms of the same disorder.

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Zur Frage derschutzimpfung bei den Veinbanding-viren. (Vorläufige Mitteilung.) (On the question of protective inoculation in the veinbanding viruses. (Preliminary notes.) Nachrichten. Bl. Deut. Pflanschulzd. **17**(4): 32–33, 1937.

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Die Viruskrankheiten der Kartoffel. (The virus diseases of potato.) Kartoffel-Zeitung **27**(21): 2–5, 1937.

————————
Die Resistenzzüchtung gegen den Kartoffelabbau im Lichte der Virusforschung. (Breeding for resistance to potato degeneration in the light of virus research.) Züchter, **9**(1): 13–15, 1937.

A study of the practical features of the problem.

————————
Fortgeführte Untersuchungen mit verschiedenen Stämmen des X-Virus der Kartoffel (Ringmosaikvirus) (Continued investigations on various strains of the X virus of the potato ring mosaic virus.) Phytopath. Zietschr. **10**(1): 31–41, 1937.

A study of strains which the author places in two groups.

Ueber ein "Veinbanding-virus" der Kartoffel. (On a veinbanding virus of potato). Phytopath. Zeitschr. **10**(1) : 17–29, 1937.

Ueber eine äusserst labile Linie des X-Mosaikvirus der Kartoffel. (On an extremely unstable strain of the X-mosaic virus of the potato.) Phytopath. Zeitschr. **10**(5) : 467–479, 1937.

Viruskrankheiten und Kartoffel-züchtung. Forsch-ungsdienst. 5(7) : 334–338, 1938.

Kokin, A. I.
(Physiological investigation of tobacco plants infected by the common mosaic virus.) Summary Scient. Res. Work Inst. Plant Prot. 1935, Leningrad p. 511, 1936.

Fiziologischeskoe izuchenie vredonosnosti obyknovennoi mosaiki tobaka Dubeck Nikitskli No. 44. (Physiological study of the injuriousness of common mosaic disease of tobacco Dubeck Nikitsky No. 44.) Zashch. Rast. (Plant Prot. Leningrad. **12**: 95–112, 1937.

Transpiration is reduced, assimilation is diminished and the soluble carbohydrate lower in diseased than in healthy plants. The protein nitrogen, proteid and nicotine higher in the diseased than in the healthy plants.

Koltermann, Alwin
Die Keimung der Kartoffelknoll und ibr beimflusung durch Krankheite. Angew Bot. **9**: 289–339, 1927.

Kostoff, D[ontcho]
Something about sterility of pollen from mosaic tobacco plants. Genetica **15**: 103–114, 1933.

Virus and genic reactions in morphogenetic physiogenetic, and phylogenetic aspects. Phytopath. Zeitsch. **9**(4) : 387–405, 1936.

A very interesting paper in which it is shown that certain phenomena, such as variegations may follow either genes or viruses.

Cytogenetic aspects for producing *Nicotiana tabacum* forms localizing tobacco mosaic virus. Phytopath. Zeitschr. **10**(6) : 578–593, 1937.

The author studied 45 species of Nicotiana and many crosses. He states that the problem is complicated by the absence of immune varieties. Environment is an important factor in development of symptoms.

Kotte, W.,
Die Farn-oder Fadenblättrigkeit der Tomate. (Fern or thread leaf of the tomato.) Z. Pflkrankh. **67**(2) : 65–72, 1937.

This disease appeared in the Baden nurseries in plants grown from English seed. In some cases fruit production was completely inhibited.

Kramer, M.

As doencas de virus das plantas. (Virus diseases of plants.) O Biologico (Brazil) 3(2) : 51–54, 1937.

Brief popular descriptive notes of the work of other investigations.

O reconhecimento das doencas de virus das plantas. (How to recognize virus diseases of plants.) O Biologico 3(11) : 331–336, 1937.

Popular statement giving the most conspicuous symptoms of virus diseases.

Kriokner, Emil O[tto Oscar von]

Die Blatrollkrankheit der Kartoffeln. (Leaf-roll disease of potatoes.) Deutsch Landw. Presse 45(4) :, 1918. (Zeit. Pflanzenk 29 : 54, 1919.)

Review of O. Appel's paper.

Krishnaswami, C. S.

Studies in disease resistance in crop plants in the Madras Presidency. II. Estimation of disease resistance in sugar cane mosaic. Proc. Indian Acad. of Science 6(6) : 481–490, 1936.

The author summarizes his results as follows: "It is seen that (1) great differences in susceptibility to mosaic are exhibited in the varieties of sugar cane, (2) that most commercial varieties are susceptible to this disease, (3) that some highly susceptible varieties are tolerant to the disease, (4) that a few immune varieties exist and could be made use of as parents, (5) that certain varieties which escape infection under one set of conditions may take the disease under other conditions, and (6) that though the disease is systemic in certain varieties some recover from the disease and there is a possibility of the covering plant acquiring permanent immunity."

Kunkel, L[ouis] O[tto]

Aster yellows and its control. Flor. Exchange Host. Trade World 85 : 13–17, 1935.

Popular account.

Virus diseases of plants, twenty five years of progress, 1910–35. Mem. Brooklyn Bot. Gard. 4(7) : 51–55, 1936.

A brief review.

Peach mosaic not cured by heat treatment. Amer. Journ. Bot. 23(10) : 683–686, 1936.

The author conducted experiments on material received from Colorado and found that the disease was not inactivated in bud sticks at 35°C., 42°C., or 50°C. for periods of time near that which the tissues can endure.

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Heat treatment for the cure of yellows and other virus diseases of peach. Phytopathology **26**(9) : 809–830, 1936.

This paper gives the results of extensive studies. Trees with yellows, little peach, red suture and rosette were cured with this treatment. Potted trees with yellows were cured in a room temperature of 34.4° to 36.3°C. The time for different parts of the trees varied. Dormant trees were cured by immersing in water at 50°C. for 10 minutes. Rosette was more difficult to control that the other diseases.

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Effect of heat on ability of *Cicadula sexnotata* (Fall.) to transmit aster yellows. Amer. Journ. Bot. **24**(5) : 316–327, 1937.

When insects infected with this virus were subject to heat of one day or longer at about 31° to 32°C. they lost the power to transmit the virus temporarily. When submitted to this temperature for 1 to 11 days they regained the ability to transmit the virus in from a few hours to a few days. The longer the treatment the longer the time required to regain the ability to transmit. It is believed that the short treatment inactivates a part of the virus and that long treatments cause complete inactivation. It is believed that the virus not completely inactivated increases in the insect. After the heat treatments the insects transmit strains which are unchanged in passage from plant to plant.

Field studies show that the transmission of this virus is greater during the latter part of the growing season when the plants are most resistant. It is suggested that the midsummer temperatures inactivate to some extent, the virus in the insects at that time.

Lackey, C[harles] F[ranklin]

Restoration of virulence of attenuated curly top virus by passage through susceptible plants. Journ. Agric. Res. **55**(6) : 453–460, 1937.

Virus that has been attenuated by passage through *Chenopodium murale* has been restored in some cases by passage through cotyledon sized sugar beets. Also by passage through *Lepidium nitidum* and *Erodium cicutarium*.

Larson, R. H., & Walker, J. C.

Properties and host range of a cabbage mosaic virus. Phytopathology (Abstact) **28**(1) : 13, 1937.

Lasinio, E.

Gialume infettivo des pesco. (Infectious yellows of the peach.) Note Fruticulture Pistois **14**(12) : 205–208, 1936.

Latimer, L. P.

The relation of cultural practices to a marked out break of cork in McIntosh apples in Northern New England. Proc. Amer. Soc. Hort. Sci. **26** : 149–150, 1930.

The author describes all forms of bitter-pit disease of apple and considers them the same disease.

Lauffer, Max A.
The molecular weight and shape of tobacco mosaic virus protein. Science **87**(2264): 469–470, 1938.

Lavin, G. I., & Stanley, W[endell] M[eredith]
The ultraviolet absorption spectrum of crystalline tobacco mosaic virus protein. Journ. Biol. Chem. **117**(3): 269–274, 1937.

They summarized their work as follows: "The ultraviolet absorption spectrum crystalline tobacco mosaic virus protein has been determined and found to agree essentially with the destruction spectrum previously found for the virus agent in purified preparations . . . . . It has been possible to demonstrate the presence of the virus protein in the partially purified juice from mosaic-diseased Turkish tobacco plants by means of ultraviolet absorption spectrum measurements."

Leake, H. M.
Mosaic and the nature of virus disease. Int. Sugar Journ. **37** (444): 460–461, 1935.

Lebard, P[aul]
Relations entre l'altitude, l'humidité et les substitutions de dégénérescence de la pomme de terre. (Relation between altitude, moisture and potato degeneration.) Compt. Rend. Acad. Agric. (France) **16**(30): 999–1004, 1930.

Lee, H[enry] A[therton]
California scaly bark and bark rot of citrus trees in Philippines. Philippine Agric. Rev. **16**: 219–225, 1923.

Leemann, A. C.
Barley stripe disease. Farming South Africa. **10**(110): 207–208, 1935.

A popular account.

Lehman, S[amuel] G[eorge]
Practices relating to control of tobacco mosaic. North Carolina Agric. Expt. Sta. Bull. **297**, 7 p., 1934.

Popular.

————————, **& Johnson, James**
Soil overwintering of tobacco mosaic. The Ext. Pathologist **14**: 45–47, 1934.

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Contaminated soil relation to the epiphytology of tobacco mosaic. Phytopathology (Abstract) **27**(2): 133, 1936.

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Ruffle leaf of tobacco. Phytopathology (Abstract) **28**(1): 14, 1938.

Lejeune, J. B. H.

La rosette de l'arachide. Étude faite par la Station Experimentale de l'arachide Bombay. (Peanut rosette. Studies made at the presente Experiment Station, Bombay.) Agric. et Elev. Congo Belge **10**: 107–108, 1936.

Studies made on peanut rosette transmitted by *Aphis laburni.*

Lesley, J[ames] W[yvill]

A study of resistance to western yellow blight of tomato varieties. Hilgardia **2**: 47–65, 1931.

Some varieties of tomatoes proved to be resistant to the curly top virus of the sugar beet. "The resistance is weak and seems to be due not so much to tolerance of the virus as to a tendency to escape infection . . . . . no significant difference was found in the length of the incubation period or in the frequency of recovery in resistant and susceptible varieties, and resistance was not increased in plants which had recovered, or in their progeny.

Levshin, A. M.

Mosaic diseases of the sugar beet. Plant Breeding Dept. Union Sugar Indus. Kieffl. **1930**: 286, 1930.

The dwarf varieties of tomatoes have been considered resistant to the virus of beet curly top. Five trials for four seasons in two places showed a 42 per cent loss in the resistant dwarf varieties and a 62 per cent loss in the susceptible varieties. The author says: "The resistance is weak and seems to be due not so much to tolerance of the virus as a tendency to escape infection. The chance of infection is influenced by the number of leafhoppers used in artificial infestation. The incubation period of the disease after artificial infestation of plants not less than 3 weeks after transplanting varied from 2 to at least 7 weeks."

Lewcock, H. K.

Yellow spot disease of pineapples. Queensland Agric. Journ. **48**(6): 665–672, 1937.

A popular account.

Likhité, V. N.

Stenosis in Gujarat cotton. Proc. Assoc. Econ. Biol. Coimbatore **3**: 15–17, 1936.

This disease has been suspected as being due to a virus but the author doubts this diagnosis.

Linn, Manson B[ruce]

A list of diseases found on economic plants on Staten Island (Richmond County), New York, from 1932–36. U.S.D.A. Plant Diseases Rept. **21**(4): 73–76, 1937.

Contains records of several virus diseases.

Loew, C[arl Benedict Oscar]

Über den Abbau der Kartoffeln. (On potato degeneration) Prakt. Bl. Pflanzenb. **14**(10–11): 308–310, 1937.

A general discussion including a discussion of *Myzus persicae* and the water holding capacity of the soil.

Lojkin, Mary

Inactivation of tobacco mosaic virus by ascorbic acid. Contr. Boyce Thompson Inst. (Abstract) **8**(4): 335. 1936.

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A study of ascorbic acid as an inactivating agent of tobacco mosaic virus. Contr. Boyce Thomp. Inst. **8**(6): 445–465, 1937.

The author summarizes this work as follows: "Autoxidation of ascorbic acid under the influence of cupric ions is associated with a capacity to inactivate highly purified tobacco mosaic virus in ascorbic acid-virus systems.

"The autoxidation of ascorbic acid which occurs in an alkaline medium or in the presence of the catalyst, hexoxidase, is not accompanied by the capacity to inactivate virus.

"The inactivation of tobacco mosaic virus in the presence of ascorbic acid undergoing reversible oxidation catalyzed by cupric ions is attributable to the formation of a specific intermediate product in the course of the autoxidation of the ascorbic acid. Neither ascorbic acid nor dehydroascorbic acid is capable of reacting directly with the virus to effect its inactivation.

"The inactivation of the virus by the autoxidation of ascorbic acid in the presence of cupric ions is inhibited by catalase, thus indicating that the intermediate product responsible for the inactivation is a peroxide."

Longley, L[ewis] E[dward]

Flower color in "broken" or mosaic tulips. Amer. Soc. Hort. Sci. Proc. **22**: 674–677, 1935.

Studies on varietal susceptibility.

Loring, H[ubert] S., & Stanley, W[endll] M[eredith]

Isolation of crystalline tobacco mosaic virus protein from tomato plants. Journ. Biol. Chem. **117**(2): 733–754, 1937.

This is a report on the isolation of a crystalline protein from tomato plants infected with tobacco mosaic virus. The crystalline protein obtained from diseased tobacco and tomato plants were almost identical.

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Comparative properties of virus proteins from a single-lesion strain and from ordinary tobacco-mosaic virus. Phytopathology (Abstract) **27**(2): 134, 1937.

"The single-lesion virus protein has approximately the same crystalline form as the ordinary tobacco-mosaic virus protein, but the crystals somewhat longer and narrower." There are some other slight differences.

————————, & **Wyckoff, Ralph W[alter] G[raystone]**

The ultracentrifugal isolation of latent mosaic virus protein. Journ. Biol. Chem. **121**(1): 225–230, 1937.

The authors studied the latent mosaic disease of potato in *Nicotiana glutinosa* and *N. tabacum.* "The protein is present to the extent of about 0.02 to 0.1 mg. per cc. of juice of infected plants and was found to reach a somewhat greater concentration in diseased *Nicotiana glutinosa* than in *Nicotiana tabacum* plants. The latent mosaic virus protein was found to be between 1,000 and 10,000 times more infectious than the original juice."

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Accuracy in the measurement of the activity of tobacco mosaic virus protein. Journ. Biol. Chem. **121**(2): 637–647, 1937.

The results of this study are summarized as follows:

A comparison of the differences in the number of lesions produced by the same percentage difference in virus protein concentration over range of from 10^{-9} to 10^{-4} gm. of protein per cc. indicates that the most favorable concentration for the comparison of different samples of crystalline virus protein is about 10^{-6} gm. per cc.

It has been shown in a number of different tests that differences in virus protein concentration of 10 per cent or greater could be readily detected by the half leaf method on *Phaseolus vulgaris* when forty to fifty leaves were used. When *Nicotiana glutinosa* was used as the test plant, the smallest difference in concentration which could be consistently distinguished with the same number of leaves was 20 per cent.

————————, & **Osborn, H. T., & Wyckoff, Ralph W[alter] G[raystone]**

Ultracentrifugal isolation of high molecular weight proteins from broad bean and pea plants. Proc. Soc. Expt. Med. & Biol. **38**(2): 239–241, 1938.

The authors isolated this protein from diseased bean and pea plants. Healthy broad bean plants yield a similar, non-infectious protein.

Loughnane, James B.

Composition of interveinal mosaic of potatoes. Nature **135** (3420): 833, 1935.

————————, & **Murphy, Paul A[loysius]**

Mode of dissemination of tobacco virus X .Nature **141**(3559): 120–121, 1938.

Experiments show that virus X is transmitted by contact, especially in the presence of strong currents of air.

Lounsbury, C. P.

Tobacco wilt in Kat river valley. Agric. Journ. Cape of Good Hope **18**: 1–22, 1906.

The symptoms described lead to the belief that it is due to a virus.

Lysenko, T. D.
(The theory of plant development and the struggle against potato degeneration in the South.) Iarovizansiia **2**: 3–22, 1935.

The symptoms described lead to the belief that is due to a virus disease.

Mader, E. O.
Potato dwarf and medium red clover. Amer. Potato Journ. **14**(9): 295–297, 1937.

Popular.

————————, **& Watkins, T. C.**
Effects of Bordeaux mixture on the control of yellow dwarf of potatoes. Phytopathology **28**(5): 375, 1938.

Plants sprayed with Bordeaux showed less symptoms of this disease than un-sprayed plants. The authors suspect that the copper sulphate counteracts the virus.

Magee, C[arles] J. [Patrick]
Virus diseases of potatoes. Year Book Veg. Grow. Assoc. New South Wales, **1937**: 49–51, 53, 1937.

Magie, R. O.
Hop diseases survey in New York, 1936. U.S.D.A. Plant Disease Rept. **20**(16): 262, 1936.

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"Slip-down", a recently discovered disease of hops. Farm Res. **4**(1): 10, 13, 1937.

This is a new disease reported from New York which causes a dwarfing of the plants beginning about the middle of June. Chlorotic ring-spots and chlorotic areas appear on the leaves. Preliminary experiments indicate that the disease is transmitted by the hop aphid.

Maier, E. A.
Mosaic control work on the south coast properties. Sugar Bull. **15**(24): 18–20, 1937.

Mains, E. B.
Observations concerning clover diseases. Trans. Indiana Acad. Sci. **37**: 355–364, 1928.

Contains some data on red clover mosaic.

Manil, P.
L'enigme des virus. (The enigma of virus.) Ann. Gembloux **43**(5): 145–163, 1936.

A review.

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A propos de la transmission par les graines de certains virus phytopathogénes. (On the transmission through the seed of certain phytopathogenic virus.) Bull. Inst. Agron. Sta. Rech. Gembloux **5**: 96–98, 1936.

————————, & **Gratia, A[ndré]**

Transmission du virus de la mosaic ordinaire du tabac a l'Orobanche, plate parasite déponoue de clorophylle. Compt. Rend. Soc. Biol. (Paris) **126**(24) : 67–69, 1937.

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Une forme nécrosante de la mosaique du tabac. (A form of tobacco mosaic producing necrosis.) Bull. Inst. Agron. Gembloux **4**(3–4) : 186–190, 1937.

Produced more severe symptoms than ordinary mosaic.

————————, & **Dricot, C.**

Relations entre le numero de lesions et la concentration du virus infectant dans les cas de la mosaique du tobac sur *Nicotiana glutinosa.* (Relation between the number of lesions and the concentration of virus in *Nicotiana glutinosa* mosaic.) Compt. Rend. Soc. Biol. (Paris) **126**(32) : 918–922, 1937.

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Quelques aspects du probleme des maladies a virus des plantes. (Some aspects of the problem of virus diseases of plants.) Ann. Ferment. **4**(1) : 26–51, 1938.

Manns, T[homas] F[ranklin], Manns, M. M., & Adams, J[ames] F[owler]

Department of Plant Pathology. Delaware Agric. Expt. Sta. Ann. Rpt. **1933–34** (Bull. **192**) : 40–49, 1935.

Additional data on plums as carriers of peach yellows and little peach. *P. myrobalan* may carry these diseases without showing symptoms. *Macropsis trimaculata* breeds abundantly on *P. munsoniana* and *P. salicina.*

————————, & **Davies F[red] R[ees]**

Dissemination of peach yellows and little peach by *Macropsis trimaculata,* Fitch. Delaware Agric. Expt. Sta. Ann. Rpt. Bull. **205** : 37–40, 1936.

It was found that the insect vector was more abundant (1) on *Prunus salicina* (oriental) than on the European species and (2) on wild than on cultivated species. It was also found that some species of spiders feed on the insects. Two species were found to be masked carriers of yellows, five of little peach.

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Dissemination of peach yellows and little peach and factors in their control. Delaware Agric. Expt. Station. Ann. Rept. Bull. **207** : 36–38, 1937.

A progress report on transmission by *Macropsis trimaculata* and the masking of these disease in several species and varieties of *Prunus.*

Marcel, M.
Étude sur la dégénérescence des Fraisieres (ser causes, comment et remédies.) (A study on strawberry degeneration, its causes and how to control it.) Bull. Soc. Nat. Hort. Fr. Ser. 6, **3**: 211–214, 1936.

Descriptions and methods of control.

Marchionatto, Juan B.
Argentine Republic: Plant diseases observed in the country. Int. Bull. Plant. Prot. **8**(11): 241, 1934.

Makes mention of the occurrence of bitter pit of apple in the Argentine Republic.

Enfermedades del trigo poco conocidas y radicadas en la región oeste de la zona triguera. (Little known wheat diseases in the west wheat region.) Bol. Ministerio Agric. Argentina **36**(4): 293–299, 1934.

Merkenschlager, F[ritz]
Nederling und Dahlem. Ein Vergleich zweier Versuchsfelder in bezug auf die Abbaufrage. (Nederling and Dahlem. A comparison of two experimental fields in relation to the degeneration problem.) Prakt. B. Pflanzenb. **14**(10–12): 299–309, 1937.

A discussion of the influence of climatic conditions on degeneration diseases.

Martin, F.
La dégénérescence de la canne á sucre. (The degeneration of the sugar cane.) Bull. Assoc. Chim. Sucrerie Distill. France et Colon. **53**(9–10: 792–794, 1936.

De la dégénérescence de quelques plantes et de la canne a sucre en particulier. (Degeneration of some plants specially of sugar cane.) Gaillon Imp. H. Jehan. 14 p., 1937.

Martin, John N.
The multinucleate condition in maize and its probable relation to the X bodies associated with mosaic diseases. Proc. Iowa Acad. Sci. **42**: 83, 1936.

Reports the finding of these bodies in corn that is apparently healthy.

Martin, Lawrence F., McKinney, H[arold] H[all], & Boyle, L. W.
Purification of tobacco mosaic virus and production of mesomorphic fibers by treatment with trypsin. Science **86**(2234): 380–381, 1937.

A description of a trypsin method.

————————, **Balls, A. K., & McKinney, H[arold] H[all]**

The protein content of mosaic tobacco. Science **87**(2258): 229–230, 1938.

The authors use three types of mosaic in comparison with healthy plants. They conclude that (1) "The total nitrogen of the plants was found to be very little changed from the normal; (2) The total protein seems also to have undergone little if any change but the accuracy of the results is probably not high enough to demonstrate small variations, since they are calculated by difference. This suggests that the virus protein is produced at the expense of the normal protein, though not necessarily directly from it. (3) In the case of the common mosaic the trypsin-resistant protein, regarded by us as virus protein, exists in smaller proportion than has been supposed previously. The amount of resistant protein was found to be greater in a susceptible variety of tobacco than in those generally considered less vulnerable. We have no proof at present, however, that the yellow mosaic virus is resistant to trypsin."

Martyn, E[dward] B[ridgeman]

Report of the Botanical and Mycological Division for the year 1933. British Guiana Dept. Agric. Div. Rpts. **1933**: 105–111, 1934.

Among other diseases reported is a mosaic disease of tomatoes showing fern-leaf type of distortion on the varieties Early Market and Market. Cowpeas were attacked by mosaic disease.

Massee, A. M.

Further observations on the strawberry Tarsonemid mite. East malling Res. Sta. Ann. Rept. **1932**: 117–131, 1933.

The plants were probably infected with a virus disease.

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The warm water treatment of strawberry runners before planting, East malling Res. Sta. Misc. Pub. No. **14**, 1934.

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On the transmission of the strawberry virus "yellow-edge" disease by the strawberry aphis, together with notes on the "Strawberry Tarsonemid mite". Journ. Pom. & Hort. Sci. **13**(1): 39–53, 1935.

The author gives the results of experimental studies. *Capitophorus fragariae* is a vector in June but not during the later part of July and August. The mite (*Tarsonemus fragariae*) was not a carrier but may cause injuries which mask the symptoms of the virus.

Capitophorus fragariae = *Myzus (Capitophorus) fragaefolii.*

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Studies on the transmission of the strawberry virus "yellow-edge" disease by insects: II-Aphid transmission experiments and period of infectibility. East Malling Res. Station, Ann. Rpt. **1935**: 171–176, 1936.

This is a record of a repetition of the work on which the first paper was based. The vector is *Capitophorus fragaefolii* and five insects are sufficient for transmission.

Studies on the transmission of the strawberry virus "yellow-edge" disease by insects. III. Aphid transmission experiments and period of infectibility. East Malling Res. Sta. Ann. Rept. **1936**: 229–231, 1937.

A record of studies which demonstrate that *Capitophorus fragaefolii* Cöple. is a vector.

Matouschek, F.

Ein Uberblic über die bisherigen Kenntnisse von den Viruskrankheiten der Pflanzen. (A survey on the present knowledge about the virus diseases of plants.) Wien. Allg. Forst-u Jagdzeitg. **52**: 114, 1934. (Wiener Landwiet. Zeit. **84**(22): 140, 1934.)

Matsulevich, B. P.

Differentsiastsüa rastital 'nykh virusov serologicheskin metodom (Differentiation of virus by the serological method.) Zasahck. Rast. (Plant Prot.) Leningrad **1936**(10): 37–49, 1936.

A review of the work of others and the results of the author's studies which indicate the possibilities of using serological reactions in the identification of viruses.

Metodika opredeleniia virusnykh bolenznei Kartofelia (Poloschatoi i morschinistoi mozaiki) Serologischeskim metodem. (The determination of virus diseases of potatoes with serological methods.) Zasahck. Rast. (Plant Prot.) Leningrad **1936**(10): 151–153, 1936.

Matsumoto, T[akashi], & Hirane, S.

(Immunological studies of mosaic diseases. V. Micro-serological tests as means of detecting the virus in a small area of mosaic tobacco plants.) Journ. Soc. Trop. Agric. Taiwan **7**: 346–350, 1935.

A description of the method.

(A further note on the serological studies of tobacco mosaic bearing malformed flowers.) Agric. & Hort. **12**(7) 1937.

The author summarizes the results as follows: "In the previous paper, the author reported that the peculiar tobacco mosaic bearing malformed flowers (cf. fig. 1–2) was confirmed by the serological tests, particularly, by "precipitin absorption", to be due to the virus complex, i.e. ordinary tobacco mosaic and potato mosaic viruses. In the present paper it is reported that he is able to separate the tobacco mosaic virus from this virus complex without impairing the infectivity of the former in the following way. The diseased plant juice (1: 3) was first reacted against the antipotato mosaic serum at different concentration, i.e. 1: 10, 1: 30, 1: 50, 1: 120, 1: 240, for 2 hours at 37°C., after which all the tubes were kept overnight in the cold room, and

in the next morning they were centrifugalized at about 3,000 r.p.m. for 30 minutes, and the supernatant liquids were used as inocula for inoculating healthy tobacco plants (cf. table 2). From the experiments it is inferred that at serum concentration of 1: 10, 1: 30, and 1: 60 the potato mosaic virus can be completely absorbed without impairing the infectivity of the tobacco mosaic virus excepting the concentration of 1: 10, in which some plants inoculated are left intact, while in the higher dilutions, such as 1: 120, and 1: 240, the potato mosaic virus is not yet completely absorbed and the juice is still capable of causing the composite disease. It is concluded, therefore, that in order to separate the active tobacco mosaic virus from the virus complex under study, the use of the serum dilution of 1: 30 and 1: 60 is recommendable.''

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(A further note on the serological studies of the tobacco mosaic bearing malformed flowers.) Fat. Sci. & Agric. Taikoku Imp. Univ. Misc. Rpt. Phytopath. Lab. 3, 5 p., 1937.

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Some serological studies on plant viruses and Bacteriophage. Proc. Second Inter. Cong. Microb. (London) p. 579, 1936.

The author gives his methods and a list of viruses studied.

Mayer, H[ans]

Die Stippfleckenkrankheit der ''Apfel'' und Kalk. Erfurt. Führ. Obst-u Gartenbau **32**: 185, 1931.

Mc Clean, A[lan] P[ercy] D[ouglas]

Streak disease of sugar cane. Proc. South African Sugar Tech. Asso. 7(933) : 73–79, 1933.

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Further investigations on the bunchy top disease of tomatoes. Union South Africa Dept. Agric., Sci. Bull. **139** : 5–36, 1935.

The virus was partially inactivated at a temperature of 60° and 70°C. and completely by a temperature above 70°C. It was transmitted to *Nicandra physaloides*, *Nicotiana tabacum*, *Petunia hybrida*, *Capsicum annuum*, *Lycopersicum pimpinellifolium*, *Zinnia elegans*, species of *Solanum* and two species of *Physalis* which produced symptoms. The virus was recovered and reinoculated into tomato.

____________, **& Halse, R. H.**

Streak disease of sugar cane: its economic importance in South Africa. Proc. South African Sugar Tech. Asso. p. 11, 1936.

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Streak disease of sugar cane. Its economic importance in South Africa. South Africa Sugar Journ. **20**(7) : 433–435, 437, 439, 441, 443, 445, 449, 450, 1936.

A review of the authors' work.

Mc Intosh, J., & Selbie, F. R.
The measurement of the size of viruses by high-speed centrifugalization. Brit. Journ. Expt. Path. **18**(2) : 162–174, 1937.

Description of equipment for the study of virus diseases.

McKay, M[arion] B[ertice]
The curly top disease. Seed World, **23**: 38, 48, 72, 1928.

Popular.

————, & Dykstra, T[heodore] P[eter]
Potato diseases in Oregon and their control. Oregon Agric. Expt. Sta. Circ. **96**, 83 p., 1930.

Popular.

McKinney, H[arold] H[all]
A mosaic disease of winter wheat and winter rye. U.S.D.A. Year Book **1926**: 763–765, 1926.

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Mosaic diseases of wheat and related cereals. U.S.D.A. Circ. **442**, 23 p., 1937.

The author gives a history of the disease, geographical distribution, spread, control and descriptions of seven viruses. Studies indicate that viruses are carried in soils east of the Mississippi river but not in the soils west of the river.

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Virus mutation and the gene concept. Journ. Heredity **28**(2) : 51–57, 1937. (Nature **140** (3531) : 33, 1937. Trop. Agric. (Trinidad) **12**(2) : 41, 1938.)

The author gives a brief review of the subject, the results of his own studies and his own views. He does not believe that we have any absolute proof as to the cause of the virus diseases.

Mc Larty, H[arold] R[oss]
A suspected virus disease of sweet cherry. Canada, Dominion Botanist Prog. Rpt. **1931–34**: 53, 1935.

Mc Leod, D[onald] J[ohn]
Spindle-tuber. Canada Dept. Agric., Canadian Expt. Farms., Div. Bot. Rpt. **1926**: 1927.

————
Report of the Dominion Field Laboratory of Plant Pathology. Fredericton. N.B., Canada Dept. Agric. Div. of Botany. Rpt. **1928**: 186–199, 1929.

Mc Rae, W[illiam]
Fungus and virus diseases. The existing organization and scope of sugar cane research and experimental work in India. Rep. Proc. Imp. Sugar Cane Res. Conf. (London) **1931**: 106–107, 1932.

India: New disease reported during the year, 1933. Int. Bull. Plant Protec. 8: 199–202, 1934.

Mc Whorter, F[rank] P[aden]
The symptoms of narcissus mosaic developed with in the plant. Phytopathology **25**(9): 896–897, 1935.

Mottling or breaking in Dame's rocket in Oregon. U.S.D.A. Plant Disease. Rept. **20**(12): 199, 1936.

A record of a virosis very similar to breaking in *Matthiola incana*. Also a record of a mottle mosaic of the cruciferous ornamental, Hespert's matronalis in Oregon.

A latent virus of lily. Science **86**(2225): 179, 1937.

A brief review of latent viruses. This virus is tulip 1 and it is latent in some species, such as *Lilium tigrinum, L. candidum* and *L. longiflorum.*

Cell inclusions in onion-yellow dwarf. Phytopathology **27**(10): 1027–1028, 1937.

Reports the finding of the cell inclusions in diseased onions.

Narcissus mosaic and early maturity. U.S.D.A. Plant Disease Rept. **22**(9): 147–148, 1938.

The antithetic virus theory of tulip-breaking. Ann. Appl. Biol. **25**(2): 254–270, 1938.

The author suggests the term "antithetic" for associated viruses which are physiologically antagonistic. These are two viruses, I & II. In the commercial broken tulips the viruses are in physiologically balanced mixtures.

Mejía, E. G.
El mosaico, matizado o rayas amarillas en la caña de azúcar. (Mosaic, motling or yellow stripes of sugar cane.) Bol. Agric. Soc. Antioq. Agric., Colombia **221**: 935–939. **288**: 966, 968–969, 1937.

Melhus, Irving E., & Henderson, W. J.
Yellow dwarf and other onion diseases. Iowa Agric. Expt. Sta. Rpt. Agric. Res. **1931**: 49, 1932.

Mention and record of the behaviour of the diseases.

Metzger, C[arl] H[enry]
Some preliminary notes on the effect of psyllid yellows on seed stock from infected plants. Amer. Potato Journ. **13**(10): 277–285, 1936.

Popular.

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Curly dwarf in Colorado. Amer. Potato Journ. **13**(11) : 316-317, 1936.

Popular.

Milbrath, D[avid] G[allens]
Peach mosaic. California Dept. Agric. 16th Ann. Rpt. Bull. **14**, p. 501, 1937.

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Virus diseases of plants in relation to agriculture. California Dept. Agric. Bull. **26**(3) : 269–274, 1937.

A very excellent popular discussion.

Milbrath, J. A.
An indication of seed transmission of mosaic virus in tomato seed. Phytopathology **27**(8) : 868–869, 1937.

The author reports transmission by seeds.

Millán, R.
El tamaño de los tubérculos que debe emplearse en las próximas siembras de papa. (Size of potato tuber that must be planted in the future.) Rev. Argentina Agron. **2** : 138–139, 1935.

Popular notes in regard to unmottled curly dwarf disease of potato.

Millar, Paul H.
Freedom from "yellows" of certain plantings of the Blackmore strawberry. U.S.D.A. Plant Disease Rept. **21**(4) : 70–71, 1937.

A Record.

Molenaar, F. A. P.
Magnesium in verband met ziekteverschipnselen bij cultuurgewassen. (Magnesium in relation to pathological symptoms in cultivated plants.) Landbouwk. Tikdschr. Wageningen **48** (590) : 637–638, 1936.

Refers to bunchy top disease of Manila hemp.

Moore, E[nid] S[tella]
A virus disease of tobacco in South Africa. Nature **129**(3258) : 544, 1932.

Account of a tobacco virus disease that resembles ringspot.

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The "Kromnek" disease of tobacco. Rhodesia Agric. Journ. **31** (1) : 9–10, 1934.

————————
Degeneration of potatoes. Farming South Africa. **10**(115) : 431–433, 1935.

Moritz, O.
Neuere biochemische und serologische Arbeiten auf dem Gebiet der planzlichen Viruskrankheiten. (Recent biochemical and serological studies in the field of plant virus diseases.) Phytopath. Zeitschr. **10**(5) : 544–558, 1937.

Muller, Paul R.
Serum diagnosis of virus diseases of tobacco. U.S.D.A. Plant Disease Rept. **22**(5) : 74–77, 1938.

The results of tests of Dr. K. Starr Chester's methods for identifying tobacco viruses. The results with tobacco mosaic was satisfactory but the results with other viruses were less satisfactory.

Murayama, D.
Studies on the mosaic diseases of tomato. Journ. Sapporo Soc. Agric. & For. **28**(133) : 215–277, 1936.

Murphy, Donald M., & Pierce, W[alter] H[oward]
Common mosaic of the garden pea, *Pisum sativum*. Phytopathology **27**(6) : 710–721, 1937.

The authors discuss the symptoms and give the results of studies with pea virus 3. The virus attacks 29 species of Leguminoseae and is transmitted by *Illinoia pisi*. The thermal death point was 60°C. and the longevity at 22°C. was less than 3 days.

————————, & ————————
A mosaic-resistant small red bean. Phytopathology **28**(4) : 270–273, 1938.

A discussion of methods and results.

Murphy, P[aul] A[loysius], Quanjer, H[endrick] M[arius], & Arthur, D[isbrowe]
Leaf roll(curl), mósaic and allied diseases. Paper read before the International Potato Conf. November, 1921. (Reviewed by Cuthbertson in Journ. Roy. Hort. Soc. 47 : 110–121, 1922.)

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Leaf-roll and mosaic, two important diseases of the potato. Ireland Dept. Agric. and Tech. Inst. Spec. Leaflet **24**, 4 p., 1923.

————————, **& McKay, R.**
The compound nature of crinkle and its production by means of a mixture of viroses. Sci. Proc. Roy. Dublin. Soc. **5** : 227–247, 1932.

————————
Nature and control of potato virus diseases. Nature **138**(3501) : 955–958, 1936.

The author recommends seed selection and discusses the relationship of *Myzus persicae*, which is a vector of the important leaf roll disease, to climatic conditions. He discusses other virus diseases briefly and records four viruses (X., F., Y. and A.) which singly or in combination produce eight diseases.

————————, & Loughnane, J[ames] B.

A comparison of some Dutch and Irish potato mosaic viruses. Sci. Proc. Roy. Dublin Soc. n. s. **21**(40) : 419–430, 1936.

The authors summarize their results as follows:

"Examination of Dutch potato mosaic diseases, carried out in conjunction with similar work in America, showed the presence of viruses X, B, Y, A, F and vein-banding virus, occurring alone and in combinations (List, p. 427).

Symptoms in some cases were absent (X, Y and F) and in others corresponded to those of simple mosaic (X), veinal mosaic (Y or A), rugose mosaic or leaf-drop (X–Y), crinkle (X–A), and interveinal mosaic (X–F).

These viruses and diseases are the same as those common in Ireland, and probably in N. W. Europe generally, but others are important in continental areas.

Other viruses were found which were similar to A or Y but not identical. It is concluded that Y and A are distinct from each other, but that each may be the type of a smaller group of closely related or practically identical viruses, analogous to the X-viruses.

Virus Y caused pronounced veinal mosaic on *Solanum nodiflorum* on which A produced no symptoms. This plant also differentiated the virus related to A and Y, as well as virus F, and proved a useful new differential host.

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A ten years' experiment on the spread of leaf roll in the field. Sci. Proc. Roy. Dublin Soc. n. s. **21** : 567–579, 1937.

A review of the work showing that the severity of the disease was correlated with climatic conditions.

Nakayama, K.

(The growth-limiting effects of dwarf genes on some organs of rice.) Japan Journ. Genetics **13**(3–4) : 196–199, 1937.

A preliminary note with English Summary.

Neal, David C[harles]

Crinkle leaf, a new disease of cotton in Louisiana. Phytopathology **27**(12) : 1171–1175, 1937.

This disease is described but cause not determined.

Neergard, P.

Virus-krankheiten der Tomaten (Tomato virus diseases). Moller's Deut. Gärtn. Zeits. **51**(21) : 237–239; 247–249; (22) : 262–263; 273–274, 1936.

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Virussydomme paa tomat. (Virus diseases of tomato.) Gartn.-Tid. Kobenhavn **52** : 113–121, 1936.

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Virussydomme paa tomat. (Virus diseases of tomato.) Gartnerlidende, 8: 11, 1936.

Gives symptoms, geographical distribution, methods of transmission and hosts of the virus diseases of tomato with bibliography.

Newton, R. G.
Experimental work with potatoes. Agric. Journ. Brit. Columbia 8: 80–81, 1923.

Newton, William, & Edwards, H. I.
Virus studies. I. The production of antisera in chickens by inoculation with potato X. Canadian Journ. Res. C. 14: 412–414, 1936.

"Chicken antiserum was produced by three wing vein inoculations with sap from *Datura meteloides*, and *Datura Stramonium* plants infected with "potato virus X". Before injection, the saps were purified by the Bawden and Pirie method. This antiserum formed a conspicuous precipitate when incubated for three hours at 37°C. with similar purified sap of these two plant species when they were infected with the X or healthy potato virus, but failed to form any precipitate when incubated in the same way with purified sap from virus-free plants. Two unknown viruses, one from spinach and the other from tomato were established as belonging to the X group by the precipitin reaction through the use of chicken antisera. The serological grouping was supported by the fact that the unknowns had similar, if not identical lethal temperature, longevities *in vitro* and host ranges as the ordinary potato virus X."

————————
Virus Studies. II. Streak X, a disease of tomatoes caused by a virus of the potato X group unassociated with tobacco mosaic. Canadian Journ. Res. C. **14**: 415–418, 1936.

"A streak disease of tomatoes was found to be caused by a virus of the potato X group unassociated with tobacco virus I. The disease markedly reduced the yield of marketable fruit in several greenhouses near Victoria. The symptoms resemble those induced by ordinary potato virus X in conjunction with tobacco mosaic. The host range, lethal temperature, longevity *in vitro*, and dilution extinction point of the virus resemble ordinary potato X. Streak X may be distinguished from ordinary potato X by the more pronounced symptoms it induces on tobacco, *Datura*, *Nicotiana glutinosa* and tomato, and particularly by the streaking and necrosis of the stems and leaves of tomato. The virus causing this streak disease could not be recovered from Irish Cobbler potatoes after an incubation period of ten days, neither did the characteristic symptoms occur on tomatoes already infected with ordinary potato virus X. The virus was recovered unchanged from X-free potato seedlings. The antigen reactions also proved that the streak virus belonged to the potato virus X group."

The menace of cherry mosaic. Better Fruit **31**(3): 7, 14, 1936.

A mottling of sweet cherry (*Prunus avium*) transmissible by budding, prunning and rubbing with juice.

------------, **& Edwards, H. I.**

Virus studies. III. Tomato diseases. Canadian Journ. Res. C. **15**: 162–167. 1937.

"Single virus streak, potato virus X, streak virus X and aucuba mosaic (tobacco virus 6) were found causing diseases of tomatoes in commercial glasshouses in British Columbia during 1936. Single virus streak was the commonest disease although greater losses were caused by the streak virus X. Aucuba mosaic was found in one case only, but was highly pathogenic. Potato virus X was present mixed with single streak, giving rare cases of mixed virus streak. Tomato mosaic (tobacco virus I) was not present as a tomato disease."

"Single virus streak serum did not give a precipitate when mixed with aucuba antigen, thus indicating that the viruses are distinct. However, a slight precipitate with tobacco virus I antigen did indicate distant relationship with this form. Although three strains of single virus streak could be distinguished by symptoms produced on tomatoes when inoculated simultaneously, these strains proved to be serologically identical."

Noble, R[obrt] J[ackson]

Virus infections in plants. Journ. Australian Inst. Agric. Sci. **1**(2): 54–57, 1935.

Notes from Presidential address delivered before the Royal Soc. New South Wales, May 1, 1935.

Spotted wilt and other virus diseases of tomatoes. Year Book Veg. Grow. Assoc. New South Wales **1937**: 46–48, 1937.

Nolla, J[osé] A[ntonio] B[ernabé]

Estudios con el mosaico o clorosis. La enfermedad "mottle". (Studies with mosaic or chlorosis. The mottle disease.) Inst. Tabaco de Puerto Rico. First Rpt. **1936–37**: 18–20, 1937.

In this first report of the Institute notes are given of the work started on the tobacco diseases mentioned.

Nyhus, P[aul]

The potato situation in Argentine. Amer. Potato Journ. **13**(7): 185–189, 1936.

Contain some data on virus diseases.

Ocfemia, G[eraldo] O[ffimaria], & Celino, M. S.

Securing disease-resistant abaca for fighting bunchy-top. Agric. & Ind. Mon. (Manila) **4**(8): 12–13, 1937.

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The probable nature of "cadang-cadana" disease of coconut. Philippine Agric. **26**(4) : 338–340, 1937.

Probably a virus disease.

Ochoa, R. H.
Algo sobre mosaico y variedades de caña en Antioquía (Colombia) (Something on mosaic and sugar-cane varieties in Antioquía (Colombia). Bol. Agric. Soc. Antioquía, (Colombia) **9**(217) : 668–672, 1936.

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Una enfermedad de la caña de azúcar. (A disease of sugar cane.) Rev. Nac. Agr. Soc. Antioquía (Colombia) **32**(391) : 841–843, 1937.

This disease is similar to mosaic but cause is not definitely known.

Ogilvie, L[awrence]
Occurrence of the rosette disease of lilies (yellow flat) in English green-houses. Bermuda Dept. Agric. Bull. **8**: 23, 1929.

————————, **& Mulligan, B. O.,**
Diseases of vegetable marrow. Bristol Agr. & Hort. Res. Sta. Ann. Rpt. **1930**: 144–145, 1931.

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A note on the occurrence of new virus diseases of the tomato in the Bristol Province. Bristol Agric. & Hort. Res. Sta. Ann. Rpt. **1935**: 104–106, 1936. (Journ. Bath. W. S. Co. Assoc. **10**(6) : 204–206, 1936.)

Descriptions of two new diseases. The symptoms are similar to those produced by cold, faulty cultivation, drought, over watering, mineral deficiencies and scorch due to leaky boilers or creosote or other fumes. They may result from smoking tobacco and cigarettes used by the laborers.

————————, **Grian, P. W.**
Progress report on vegetable diseases. VII. Bristol Agric. & Hort. Res. Sta. Ann. Rpt. **1935**: 110–117, 1936.

The greater part of this report is devoted to mosaic of lettuce. It is primarily a study of varietal susceptibility and resistance. It gives the symptoms of each variety.

Okuda, Y., & Sutoh, H.
(Biochemical investigation of mosaic diseases of tobacco plants. Part I.) Journ. Agric. Chem. Soc. (Japan) **12**(12) : 1227–1231, 1936.

————————, **Shigemathu, S., & Hanada, M.**
(Biochemical investigation of mosaic diseases of tobacco plants. Part II.) Journ. Agric. Chem. Soc. (Japan) **12**(12) : 1232–1238, 1936.

Oortwijn Botjes, J[an Gerhardus]

Vermindering van de vat baarheid voor bepaalde virusziekten bij sommize aardappelrassen. (The decrease in the susceptibility of some races of potatoes to certain virus diseases.) Landbouwk. Tijdschr. **47**(579): 651–657, 1935.

(The position of the immunity problem in the virus diseases of plants.) Tijdschr. Plantenziekten **42**(1): 1–9, 1936.

A review of recent work.

De oorzaah van het optreden van dwergmozaikiekte aardappelphanten (stekelpoppen). (The cause of the occurrence of dwarf mosaic-diseased potato plants (spring heads). Tijdschr. Plziekte. **43**(3): 60–63, 1937.

Plants with a mild mosaic disease contain stipple streak (acropetal necrosis) virus which is masked. It is the same as curly dwarf and bukett disease.

Verschil virulentie bij het virus van stippelstreepziekte in de aardappel plant. (The variation in virulence of the stipple streak disease virus in the potato plant.) Tikdschr. Plziekte. **43**(1): 1–10, 1937.

A study of the variation in stipple streak (acropetal necrosis).

Opitz, K.

Zur Fräge der Virus-übertragung in Kartoffelfeldem. (On the question of virus transmission in potato fields.) Dutsch. Landw. Pr., **63**(32): 399–400, 1936.

These studies showed that these diseases were transmitted very readily.

Osborn, H. T.

Studies on the iransmission of pea virus 2 by aphids. Phytopathology **27**(5): 589–603, 1937.

The author gives the results of his studies which include a list of host plants. The virus is inactivated in 10 minutes at 64°C., and in five days *in vitro*. The virus is transmitted by *Macrosiphum pisi, M. gei* and *Aphis rumicis*. They acquire the virus in five minutes feeding on diseased plants and are able to transmit immediately but some colonies lost this power after feeding 15 minutes on a healthy plant. However, when held without food they retain the power much longer.

Vein-mosaic virus of red clover. Phytopathology **27**(11): 1051–1058, 1937.

The author reports a new virus on red cover. It is transmitted by the pea aphid and attacks *Vicia faba, Trifolium repens, T. hybridum, T. incarnatum, Melilotus alba* and *Pisum sativum*. It is inactivated by a temperature of 10°C. for 10 minutes.

Differentiation of 5 mosaic viruses of legumes. Phytopathology (Abstract) **28**(1) : 17, 1938.

Orton, C[layton] R[oberts], & Hill, L. M.
An undescribed potato disease in West Virginia. Phytopathology (Abstract) **27**(2) : 137, 1937.

The cause of this disease is not known. It possesses some of the characters of a virus but apparently is not transmitted in the tubers.

Otero, José I[dilio], & Cook, Melville T[hurston]
Second supplement to partial bibliography of virus diseases of plants. Journ. Agric. Univ. Puerto Rico **20**(3) : 741–819, 1936.

A continuation of the work published in the above Journal. 18(1–2): 1–410, 1934 and 19(2): 129–213, 1935. This supplement contains nearly 500 additional titles.

Ott, A.
Sul mosaico del pesco. I. (Peach mosaic.) Note Fructticultura Pistoia. **15**(8) : 128–132, 1937.

Sul mosaico del pesco. II. (Peach mosaic.) Note Fructticultura Pistoia **15**(9) : 141–148, 1937.

Paine, S. G., & Bewley, W[illiam] F[leming]
Stripe disease of tomatoes. Journ. Min. Agric. **26**(10) : 998–1000, 1920.

Pal, B. P., & Tandon, R. K.
Types of tobacco leaf-curl in Northern India. Indian Journ. Agric. Sci. **7**(3) : 363–393, 1937.

The authors review the history of the disease, describe the symptoms and give the results of their experiments. They list five types of leaf-curl due to four viruses as follows: (1) tobacco leaf curl A (tobacco leaf-curl virus I), (2) tobacco leaf-curl B (tobacco leaf-curl virus 2), (3) tobacco leaf curl C (tobacco leaf curl virus 3), (4) tobacco leaf-curl D (tobacco leaf-curl virus 4) and (5) tobacco leaf curl X (a mixture of two or more of the leaf curl viruses.) Tobacco leaf curl A is probably same as "krulziekte", "Kroepoek", "faltenzwerg", gila and "krokoh".

Palm, B[jorn] T[orwald]
(The "cracked skin" disease of the beet (*Beta vulgaris* L.) Svensk Bot. Tidskr. **31**(4) : 395–399, 1937.

Pape, H[einrich]
Über eine Mosaikkrankheit der Kohlrübe. (A mosaic disease of the swede). Deutsche Landwrit. Press. Gond. **26**, 8 p., 1935.

Popular version of a previous publication.

Zur "Farn-oder Fadenblättrigkeit der Tomate". (Ringspot disease of tomato.) Zeitschr. Für Pflanzenk. & Pflanzens. **47** (12): 619–620, 1937.

Brief note.

Panse, E.,
Die Kränselkrankheit (Rosette, mosaic) bei Erdnüssen. (Curl disease (rosette, mosaic) of groundnuts.) Tropenpflanzer, **40** (5). 218–220, 1937.

Records of the disease in Senegal.

Parker E[dwin] R[oberts]
Mottle-leaf and sun-blotch disease control. California Avocado Assoc. Yearbook **1936: 149–151, 1936.**

Popular.

Parker, M. C., & Brink, R. A.
The inheritance of resistance to common bean mosaic. Wisconsin Agric. Expt. Sta. Ann. Rpt. 1931–32; Bull. **425**: 102, 1933.

Inheritance of resistance to the common mosaic virus in the bean. Journ. Agric. Res. **52**(12): 895–916, 1936.

In the summary the author writes in part as follows: "Reciprocal crosses between the mosaic-resistant Michigan Robust and susceptible Stringless Green Refugee varieties of beans reacted quite differently to the mosaic virus employed in these studies. It was found that the maternal parent governs to a large extent the reaction of the hybrid offspring." In his discussion of the results of many crosses he said: "These results cannot be explained on a simple Mendelian basis, because the reciprocal hybrids react differently. To explain the fact that the maternal parent determines to a large degree the reaction of the hybrid individuals it is assumed that the cytoplasm or some extranuclear inclusion governs the immediate reaction of the plant to the virus. The convergence of the results from reciprocal crosses in the F_2 and F_3, however, points to the conclusion that the ultimate control is nuclear but that there is a delayed expression of the action of the genes. The further assumption is necessary that certain geno-types change the reaction of the cyto-plasm more rapidly than others."

Pasinetti, L.
Ricerche sitologiche sulla "maculatura ferruginosa" (Eisenfleckingheit dei tuberi di patata.) (Histological investigation on the "iron stain" (Eisenfleckigheit) of the potato tuber.) Riv. Patol. Veg. Pavia **25**(21): 185–227, 1935.

Passalaqua, T.
Expérience de vaccination sur le *Pelargonium zonale.* (Experiences on vaccination of *Pelargonium zonale.*) Sic. Intern. Microb. Boll. Sez. Ital. **6**: 83–87, 1934.

Una probabile virosi della "*Vicia faba* L." (Note preliminare). (A probable virosis of *Vicia faba* L. (Preliminary note) Riv. Pat. Veg. **27**: 5–6, 145–148, 1937.

A disease causing a dwarfing of the plants.

Pemberton, C. E.
The insect vectors of virus diseases of sugar-cane. Proc. Fifth Congr. Int. Soc. Sugar Cane Tech. (Brisbane) **1935**: 118–120, 1936.

The author believes that *Perkinsiella vitiensis* and possibly other insects are vector of the Fiji diseases.

Penzig, O.
Yellows. Pflanzen-Teratologie **2**: 34–39, 1921.

Perdrau, J. R., & Todd, C.
The photo-dynamic action of methylene blue on certain viruses. Proc. Roy. Soc. B. **112**: 277–298, 1933.

Peterson, Paul D., & McKinley, H[arold] H[all]
The influence of four mosaic diseases of the plastid pigments and chlorophyllase in tobacco leaves. Phytopathology **38**(5): 329–342, 1938.

The authors report an increase in chloro-phyllase activity accompanied by a decrease in chlorophyll content of the tissues.

Pethybridge, G[eorge] H[erbert], & Smith, K[enneth] M[anley]
A suspected virus disease of Zonal Pelargoniums. Gard. Chron. **92**: 378–379, 1932.

Petri, L[ionello]
Sull' arricciamento (court-noué) della vite. (On leaf roll of grape.) Boll. R. Staz. Pat. Veg. **14**(2): 273–278, 1934.

A review of the author's work.

Trasmissions del virus del l'arricciamento della vite attraverao i tessuti di una varieta resistente. Atti. R. Acad. Naz. Lincei VI, Rend. Cl. Sci. Fis., Mat. e Nat. **25**(9 & 10): 413–416, 1937.

Passage through an intermediate resistant graft does not inactivate or attenuate the virus.

Peyronel, B.
Bitter-pit of apples. Bull. R. oc. Toscana Ortic 4 ser. **17**(11–12): 151–159, 1932.

Pfankuch, E., & Lindau, G.
Zur Biochemie des Kartoffelabbanes II. Biochem. Zeitschr. **277** (1–2): 129–138, 1935.

Piemeisel, R[obert] L[ouis]

Land-improvement measures in relation to a possible control of the best leafhopper and curly top. U.S.D.A. Cir. **416**: 1–23, 1936.

The studies reported in this circular were made to show that the application of certain land-improvement measures would aid in the control of *Eutettix tenellus* and the curly top of sugar beet. The author made a survey throughout southern Idaho and found that the insects are produced in economic numbers on the weed hosts on abandoned, weedy fallow, burned over or heavily grazed lands. These weed host will be replaced ultimately with plants that are not hosts for the insects.

Pierce, W[alter] H[oward], & Walker, J. C.

The development of mosaic resistant Refugee beans. Canner **77** (26): 7–9. 1933.

Popular.

The identification of certain viruses affecting leguminous plants. Journ. Agric. Res. **51**(11): 1017–1039, 1935.

The author reports the following distinct viruses obtained from the common beans (*Phaseolus vulgaris*) in Idaho. Common bean mosaic virus (bean virus 1), yellow bean mosaic virus (bean virus 2), enation pea mosaic virus (pea virus 2), common pea mosaic virus (pea virus 2), common soy bean mosaic virus (soy bean virus 1) and broad bean local lesion virus obtained from red clover.

Legume viruses in Idaho. Phytopathology **27**(8): 836–843, 1937.

Some strains of bean virus 2 were more severe than others. Most legumes were subject to more than one virus. Diseases should be designated by viruses rather than by symptoms. One virus usually predominates on each host species. Pea virus 3 was the cause of most infections on red clover and bean virus 2 for most infections on sweet clover; it is possible that the results may be different in different localities. Some legume hosts may serve for the overwintering of some viruses; e. g. bean virus 2 which causes yellow mosaic of beans overwinter in sweet clover and pea virus 3 in red clover. The most important viruses in peas and beans in Idaho were pea virus 3 and bean virus 1.

Pinckard, J. A.

The effect of flue-curing on the survival of ordinary tobacco virus 1. Phytopathology (Abstract) **28**(1): 18, 1938.

Piovano, A. P.

Contribución para el estudio de las enfermedades por virus filtrables de las plantas cultivadas en Mendoza. (Contribution to the study of virus diseases of cultivated plants in Mendoza.) **9**(2): 1190–1202, 1937.

Pirone, P. P.
Geranium crinkle in New Jersey. U.S.D.A. Plant Disease Rept. **22**(9) : 146, 1938.

Pittman, H[arold] A[mbrose Jacques]
Fig leaf mosaic. Journ. Dept. Agric. West Australia 2nd Ser. **12**(2) : 196, 1935.

Plakidas, A[ntonios] G[eorge]
Leaf variegation of the Blackmore strawberry in Louisiana. U.S.D.A. Plant Disease Rept. **18**(5) : 46, 1934.

Poeteren, N[icolas] van
Verslag over de worksaamheden van den plantenziekten krundugen Dienst. in de jaren 1920 en 1921. Verslag en Mededeel. Plantenziekten kundigen Dienst Wageningen **27**: 926, 1922.

A dry temperature of 50° C. for 24 hours failed to kill virus of leaf roll in infected tubers.

Die Bekaempfung der Viruskrankheitien bei Kartoffeln, mit besonderer berueksichtung der Erzengung hochwertigen saatguter in den Nierderlanden. Rapp. Nat. Sect. V, Theme 9, (No. 11) Congr. Intern. Hort., (Rome), 11, 1935.

Pole Evans, I. B. see. **Evans, I[lltyd] B[uller] Pole**

Poos, F. W., & Wheeler, Nancy H.
On the hereditary ability of certain insects to transmit diseases and to cause disease-like injuries to plants. Journ. Econ. Ent. **27**(1) : 58–69, 1934.

The authors give a review of the literature and results of experiments which lead to the following conclusions: (1) *Empoasca fabae* inherits the power to cause disease like injuries in legumes and some other crops; (2) *Myzus persicae* when infected with the virus of spinach blight do not transmit same to their offspring.

------------, **& Westover, H. L.**
Alfalfa yellows. Science* **79**(2049) : 319, 1934.

Porter, D. R., & Henderson, W. J.
Onion diseases. Trans. Iowa Hort. Soc. **63**: 240, 1929.

Reference to yellow dwarf of onions.

Post, T[helma] B.
Mosaic disease of roses in Arkansas. U.S.D.A. Plant Disease Rept. **19**(7) : 98–99, 1935

Price W[ililam] C[onway]
Classification of lily-mosaic virus. Phytopathology (Abstract) **27**(2) : 138, 1937.

------------, & **Gowen, J[ohn] W[hittemore]**

Quantitative studies of tobacco-mosaic virus inactivation by ultra-violet light. Phytopathology **27**(3): 267–282, 1937.

The authors summarize their work as follows: "The survival values of tobacco-mosaic virus exposed to ultra-violet light follow a simple exponential curve. If we regard radiant energy as absorbed in discrete units, this curve may be obtained when one unit of energy absorbed in a virus particle is sufficient to cause its inactivation. The rate of inactivation will depend on the amount of energy incident to the virus. The data show that when the virus is most purified (in a solution of crystalline material) and the solution has least extraneous matter to absorb the energy, the rate of inactivation is greatest. Adding juice of healthy tobacco plants to purified virus lowers the rate of inactivation. The rate for the crystalline material plus juice of healthy tobacco plants is essentially the same as that for the virus in juice of diseased plants. The rate of inactivation for virus in non-purified dried juice follows essentially the same curve as that for the wet material, except that a portion of the virus fails to become inactivated even when exposed for long periods of time. This is believed to be due to the fact that dried virus particles, because of their fixed position, are sometimes overlain by other materials and thus shielded from the ultra-violet light."

Classification of lily-mosaic virus. Phytopathology **27**(4): 561–569, 1937.

A record of a number of cross inoculation which indicate that this virus is the same as cucumber mosaic virus.

------------, & **Wyckoff, R[alph] W[alter] G[raystone]**

The ultracentrifugation of the proteins of cucumber viruses 3 and 4. Nature **141**(3574): 685–686, 1938.

Prien

Ist eine Bekämpfung der Kartoffelabbanes möglich? (Is a campaign against potato degeneration practicable?) Deutsch. Landw. Pr. **63**(5): 57, 1936.

Recommends growing of excised eyes.

Pruthi, H. S.

Entomological investigations on the spike disease of sandal. XIV, Jassidae (Homopt) Indian For. Rec. **30**, 1934.

------------, & **Samuel, C. K.**

Entomological investigations on the leaf-curl disease of tobacco in North Bihar. I–II. Indian Journ. Agric. Sci. **7**(4): 659–670, 1936.

I. Transmission experiments with some suspected insect vectors.
II. An alternative host of the virus and the insect transmitter.

Puchner, H.

Neue Gedank en über das "Rollen" und das "Kranseln" de Kartoffelbeattes. Der Kartoffelbau **10**: 161–168, 1926.

Leafroll is said to be due in part to moisture content and relations.

Purdy, [Beale] Helen A[lice]

Possible relationship of Stanley's crystalline tobacco mosaic virus material to intra-cellular inclusions present. Contr. Boyce Thompson Inst. **8**(4): 333, 1936.

This is an abstract of a paper presented at the meeting of the American Phytopathological Society, December 28, 1936, in Atlantic City, New Jersey. The author studied *Nicotiana tabacum* infected with strains of tobacco mosaic virus and found striated material described by Iwanowski (1903) and the X bodies described by Goldstein (1924). The striated material or crystals are similar to those obtained by Stanley's method.

Relation of Stanley's crystalline tobacco-virus protein to intra-cellular crystalline deposits. Contr. Boyce Thompson Inst. **8**(5): 415–431, 1937.

The author gives a brief review of Stanley's work. The crystalline tobacco-virus protein used in these studies was isolated from several sources and tested with antiserum.

"It is suggested that the intracellular crystalline plates may be more complex in chemical constitution than Stanley's crystalline tobacco-virus protein."

"It is concluded that the intracellular crystalline deposites are the source of Stanley's crystalline tobacco-virus protein because: A.—The two crystalline compounds are present in large amounts. B.—There is a striking similarity in the gross appearance of the needles precipitated in the cell and isolated from virus extract. C.—The acidity and alkalinity at which Stanley reports denaturation of the protein corresponds closely to the reactions at either end of the pH range at which the intracellular crystals go into solution and are not subsequently recrystallizable."

"It is concluded that concentration is an important factor in the intracellular crystallization of tobacco-virus protein."

The intracellular crystallization of Stanley's tobacco virus proteins. Journ. Bact. (Abstract) **33**(3): 336–337, 1937.

Putman D[oland] F.

Comparative studies in potato virus diseases. Canadian Journ. Res. C **15**(3): 87–107, 1903.

Reports and describes potato mosaic under the name of "yellow mottle". It belongs to the latent or X virus group.

Puttemans, Arsene
Informacoes sobre "Doencas de Degenerescencia" de Batatoira no Brasil. (Degeneration diseases of potato in Brasil.) Rev. Agric. Brasil 9(3-4): 103-111, 1934.

A leaf roll disease.

Quanjer, H[endrik] M[arius]
Vergelijking tusschen den gezondhertstoestand van schotsche en nord hollandsche Pootaardappelen. Tijdschr. Plantenziekten **31**: 7-10, 1925.

Iets over de virusziekten van tropische cultuur-gewassen. (An account of some virus diseases of tropical plants.) Landbouwk. Tijdschr. Wageningen **50**(611): 324-338, 1938.

Account of virus diseases of tobacco, cassava, *Soja*, *Arachis*, *Musa*, sugar cane and rice.

Racicot, H[oméra] N[oé]
Bean mosaic. Canada Rpt. Dominion Botanist **1926**: 57, 1926.

Raleigh, W[alter] P[atrick]
An abnormal graft reaction in potato resulting from a virus infection of a scion on a resistant stock. Phytopathology **26** (8): 795, 1936.

The author found that when scions containing latent mosaic virus (X-virus) or mild-mosaic-virus were grafted on certain stocks, the plants developed a rolling of the leaves and aerial tubers. He says that "Results, thus far, indicate that the general principle of grafting infected scions on potatoes to determine their reaction to the virosis concerned may be of much value in studies on resistance to virosis."

Ramanatha Ayyar, V., & Balasubrahmanyan, R.
Occurrence of sterile plants in Bengal gram, (*Cicer arietinum*). Madras Agric. Journ. **21**(9): 392-393, 1933.

The authors report the occurrence of this disturbance for three consecutive seasons. After close observations and studies, there was no fungi, insects, physiological cause or any other agent to make responsible for the disease. They concluded judging from the behavior of the disease that it is caused by a virus.

Ramsborn, K.
Zur Physiologie des sog. Kartoffelabbaus. II Über eine formative Virkung von Beteroauxin auf das Austreiben von Kartoffelknollen. (On the physiology of the so-called potato degeneration. II. On a formative action of beterauxim on the germination of potato tubers.) Planta, **26**(5): 737-750, 1937.

Raphael, T. D.
Virus diseases in straw-berries. Tasmanian Journ. Agric. n. s. **8**(3): 152-155, 1937.

Ravas, L.

Essais de traitement fu court-noué. (Tests on the treatment of "court-noué"). Ann. Ecole Nat. Agr. Montpellier **20**(3): 213–218, 1930.

Rawlins, T[homas] E[lsworth], & Takahashi, William N.

The nature of viruses. Science **87**(2255): 255–256, 1938.

The authors call attention to a number of papers published during the last six years and conclude: "It is obvious that much of the above speculation is based on meager evidence; it is presented with the hope that it may stimulate further research in this field rather than that it may enable the reader to reach a conclusion regarding the nature of virus."

Reddick, Donald

Seed transmission of potato virus diseases. Amer. Potato Journ. **13**(5): 118–124, 1936.

A review of the subject and the results of the author's experiments. In the first part of the paper the author says: "Transmission of any virus diseases through the true seed of the potato has not been established with certainty." In the summary he says: "Seed transmission of the potato disease acropetal necrosis, caused by a virus occurs in a low percentage of cases. Some evidence is presented which indicates that entry of the virus into the embryos may be affected by the pollen." "Inferential evidence that acronecrosis and leaf-roll, also caused by virus, may be transmitted through the true seed is also presented.

Reed, H[oward] S[prague]

Cytology of leaves affected with little-leaf. Amer. Journ. Bot. **25**(3): 174–186, 1938.

Reeves, Enoch L.

Mottle leaf of cherry. Washington State Hort. Assoc. Proc. **31**: 85–89, 1935.

Popular. Thus far the disease has been transmitted by budding and grafting only.

Reinking, O[tto] A[ugust]

Bean mosaics, their relation to the canning crop. Canner **84** (17): 20, 1937.

A popular review of the situation.

Rhoads, A. S.

Observations on psorosis of citrus trees in Florida. Citrus Ind. **18**(5): 8–9, 16–17, 1937.

A summary of our knowledge of the subject and results of surveys made in 1927 and 1936.

Rhode, G.

Kahmangelerscheinungen und Kartoffeln. Kali im Stoffwechsel der Pflanzen unter besonderer Berücksichtigung der Kalimangelers-cheinungen au Kartoffeln. D. Kartoffelbau **19**(1): 73–78, 1935. (D. Kartoffelhandel **21**, No. 47, 1935.)

Richter, H.

Eine noch nicht aufgeklärte Lupin-krankheit. (A hitherto unexplained Lupin disease.) Nachrichtenbl. Deutsch. Pflanzenschutzdinst. **14**(9): 81–82, 1934.

An obscure disease with symptoms of virus diseases.

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Die Gelbsucht der Sommerasten. (Yellows of China asters.) Nacher B. Deutsch.. Pfl. Sch. Dienst. **16**(7): 66–67, 1936.

A report on the presence of this disease in Germany.

Riemsdijk, J. F. van

Physiologisch Onder-zock van de "Vergelinsziekte" van Voederbeiten en de schade dor dize Ziekte Ceweegebracht. (Physiological investigation of and damage done by yellowing disease of fodder beets.) Tijdschr. Plantenziekten **41**(12): 317–329, 1935.

In yellow diseased plants the dry content of the leaves is larger than in healthy plants; the dry contents of the roots less; and number of leaves greater. There is an accumulation of starch in the leaves which is due to a disturbance of the translocation.

Rienhoff, William Sr.

Principles and foibles of cancer research in regard to etiology and nature. Waverly Press, Inc., Baltimore, Maryland 200 p., 1936.

The author is a Doctor of Medicine and discusses the subject from the standpoint of his profession. The book is interesting to the plant pathologist because several pages are devoted to virus diseases of plants. The work is summarized in part as follows:

"The cancer cell is a dualistic organism in constitution and action, consisting in a living filterable virus and a fixed living body cell. The interaction between the two is that of an actual cell invasion of the germ into a cell deficient in its impermeability; and to its progress into the nucleus where cancer development really starts. Sarcoma is the outcome of a germ invasion in sub-cutaneous lesions, by a circuitous route directly into a primarily damaged cell; cancer is the outcome of an invasion by a direct route into a defective cell of external or internal surfaces in the process of repair or regeneration."

This paper is worthy of the attention of the students of both animal and plants viruses.

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Protein-virus as a morbific factor. A mimeograph manuscript, 10 p., 1937.

For comparison with pages 92 and 125 of the preceding. It is devoted entirely to a virus and attention is given to the recent work of

Stanley. It is unfortunate that it was not published in a journal which would give it a wider distribution than it can receive as a mimeograph publication.

Rainmuth, E[rnst] F[riedrich]
Virusinfektion und abbau. (Virus infection and degeneration.) Kranke Pflanze **14**(5) : 81–86, 1937.

Rietsema, I.
De mozaiekziekte der Franboszen. (The mosaic disease of raspberries.) De Fruitteelt **28**(12) : 206–212, 1936.

A study of the varietal resistance to the disease and efforts to develop resistant strains.

Riker, A[lbert] J[oyce], & Riker, Regina (Emma) S[tockhausen]
Introduction to research on plant diseases. Published by the authors at Univ. Wisconsin, 1936.

Chapter VI is devoted to methods for the study of virus diseases.

Rischkow, V[itolij] L.
(Mutations and diseases of the chloroplast.) Moscou, 192 p., 1933.

Contains a discussion of chlorosis, mosaic and related virus diseases.

-----------, **& Karatschevsky J., & Michailova, P. V.**
Ueber die Fruchtverholzung bei Tomaten. Verläufige Mitteilung. (On the woodiness of fruit in tomatoes. Preliminary note.) Zeitschr. Für Pflanzenkrankh. u. Pflanzenschutz. **43** (8–9) : 496–498, 1933.

A brief description of a disease of tomatoes believed to be a previously undescribed virus disease in the Crimea, characterized by woodiness of the fruit as reported on passion-fruit from Australia, known as "stolbur".

Ultravirus und Immunität. (Ultravirus and immunity.) Rpt. 3rd. Int. Congr. Compar. Patho. **1**(2) : 153–166, 1936.

A review of the subject.

Immunity of plants from diseases caused by filterable viruses. Bull. Appl. Bot. Select., 1937, Ser. **2**(11) : 81–105, 1937.

A review of the work done and a bibliography of 70 titles.

Rivera, V.
Prospettive di studio nelle malata da "virus" nelle piante. (Studies on virus diseases of plants.) Nuovo Giornale Bot. Italiano Firenze **41**(4) : 776, 1934. (Int. Bull. Plant Prot. **9** (4) : 99, 1935. Atti Della Soc. Prog. Sci. **23**(3) : 139–140, 1935.)

Roland, G.

Étude de la jaunisse de la betterave. (Study on beet yellowing.) Rev. Path. Vég. Ent. Agric. **23**: 185–207, 1936.

Recherches sur la jaunisse de la betterave quelques observations sur la mosaique de cette plants. (Research on sugar beet yellowing, together with some observations on mosaic of this species.) Sucr. Belge **55**(11): 213–217; (12): 231–241; (13): 263–268; (14): 289–293, 1936.

The yellowing shows accumulation of starch in the leaf and gummosis in the phloem. It is transmitted by grafting and by *Myzus persicae* and *Aphis fabae* but not sap inoculation. It resembles potato leaf roll. It overwinters in the roots. The symptoms are intensified by light and dryness. The mosaic shows a variety of symptoms which makes a definite description difficult. *Myzus persicae* is a vector. The symptoms are retarded by light.

Rosen, H[arry] R[obert]

Mosaic disease of roses in Arkansas. U.S.D.A. Plant Disease Rept. **19**(2): 98–99, 1935.

Rosenfeld, Arthur H[inton]

Some notes on varietal resistance to streak disease in Egypt and Natal. Intern. Sugar Journ. **40**(471): 99–100, 1938.

Rosa, A. Frank, & Vinson, C[arl] G[eorge]

Mosaic disease of tobacco. Action of proteoclastic enzymes on the virus fraction. Nature of the virus from various species of plants. Missouri Agric. Expt. Sta. Res. Bull. **258**, 19 p., 1937.

The authors conclude that the inactivation of the virus by trypsin is the result of absorption. Pepsin inactivates slowly and at pH 3. The authors studied virus preparations from 19 species of plants. They describe a method of purifying viruses. The authors believe that the inactivation of a virus is the result of adsorption and not to the enzyme action of the host plant.

------------, **& Stanley, W[endell] M[eredith]**

Partial reactivation of formalized tobacco mosaic virus protein. Proc. Soc. Expt. Biol. & Med. **38**(2): 260–263, 1938.

Tobacco mosaic virus protein that had been partially or completely inactivated by formaldehyde was made active by dialysis at pH 3.

Rous, L.

Essais contre le court-noué. (Experiments on the control of "court noué".) Progr. Agr. Vitic. **107**(12): 295–287, 1937.

A report on failures to control the disease.

Ruhland, W. & Michael, G.

Zur Physiologie des sog. Kartoffelabbanes. (On the physiology of the so-called potato degeneration.) Ber. Verh. Akad. Wiss. Leipzig **88**(1) : 3–10, 1936.

A study of physiological disturbances. The writers are of the opinion that their observations do not conflict with the virus disease theory of degeneration.

Ryakhovski, N. A.

(Determination of the injuriousness of tomato diseases and method for their control.) Plant Prot. Leningrad. **1935** : 88–91, 1935.

Sabaschnikoff, A. W.

Der Kartoffelabbau und die Bekämpfungmittel. Osteurop Land-Zeitg. **13**(12) : 1–6, 1936.

Salaman R[edcliffe] N[athan]

Report on a scheme for raising virus free potato stock. Cambridge School Agric. Mem. **7**, 41 p., 1935.

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Immunity to virus diseases in plants. Third Cong. Pathol. Int. Comparée. Athens, 1936, **1** : 167–178, 1936.

A very excellent review of the subject including comparisons with immunity in animals. The author says: "The study of immunity in plants has suffered not a little from the application to it of ideas borrowed from animal immunology. Such views have dictated the experimental approach of many workers to the problem, no less than the explanation of such results as have been obtained, and of the phenomena observed in nature."

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Acquired immunity against the "Y" potato virus. Nature (London) **139** (3526) : 924–925, 1937.

This paper describes tobacco plants completely immune and potato plants partly immune against the virulent form. It was obtained by transmitting the virulent form through *Schizanthus retusus* or into the root fibers of tobacco plants.

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Plant viruses and their relation to those affecting man and animals. Lancet **232** : 827–833, 1937.

This is a lecture given before the Southampton Medical Society, January 13th, 1937. It is a review of our knowledge of the subject. The author concludes by saying: "Although the incidence of virus diseases in our field and crops and glasshouses has undoubtedly increased, there is no reason for undue pessimism. What is needed is more research on virus diseases and a closer understanding between the pathologist and the plant breeder. It is the latter who needs to realize that when by his breeding methods he gives us a large and ever larger crops, bigger and whiter fruits, and the like, he has almost certainly

discarded in route a number of hereditary genes which alone or in combination with other may be responsible for that vague but important character-constitution.''

Salmon, E[rnest] S[tandley]
On the appearance of sterile dwarfs in *Humulus lupulus* L. Journ. Genet. **3**: 195, 1914.

————————, **& Ware, W[illiam] M[elville]**
Nettlehead disease of hops. Journ. South Eastern Agric. Coll. **27**: 95, 1930.

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Diseases of hops. Journ. Inst. Brewing n. s. **41**(6): 235–237, 1935.

Recognizes 3 virus diseases—nettlehead, mosaic and chlorotic diseases.

————————, **& Ware, W[illiam] M[elville]**
Dept. of Mycology. Journ. South Eastern Agric. Coll. Wye, Kent. **37**: 15–28, 1936.

A record of a virus tip which is called ''fluffy tip.''

————————
Fungus and virus diseases of the hop. II. Journ. Inst. Brew. **42**(4): 184–186, 1936.

Includes one new disease probably due to a virus, ''fluffy-tip'' or ''bunchy-top''.

Sastri, B. M., & Sreenivasaya, M[ontnahalli]
Insect transmission of spike-disease. Current Sci. **3**(1): 27–28, 1934.

————————
Physiology of the spike disease of sandal. Proc. Indian Acad. Sci. **3**(6): 444–449, 1936.

Scammell, H. B.
Cranberry false blossom from the viewpoint of the grower. Proc. Wisconsin State Cranberry Grow. Assoc. **44**: 8–11, 1931.

Schander, Staar
Bericht über die Tätigheit des Instituts für Pflanzenkrankheiten 1929–30. Landw. Jahrb. **72**: 62–91, 1930.

Considers mosaic a disease of the nucleus.

Scharff, J.
Celery mosaic. California Cult. **83**(24): 818–819, 1936.

Schenk, P. J.
Ziektenbestryding bij Amaryllis en Gloxihie. Floralia **55**(10): 147–148, 1934.

A disease of Gloxinia supposed to be due to a virus and a mosaic disease of Amaryllis.

Schick, R.
Die Wichtigsten Viruskrankheiten der Kartoffeln. Ihre Bedeutung für den Abbau und ihre Bekämpfung. A. Metzner, Berlin, 40 p., 1936.

Schlumberger, Otto
Abbaukrankheiten der Kartoffel. Wochenbl. Landesbauternsch. Sa. (Freistaat) **84**(3) : 432, **94**: 131–132, 1936.

Schmidt, E[rnest] W[illy]
The beet bug. Carrier of a dangerous virus disease. Brit. Sugar Beet Rev. **10**(2) : 43–46, 1936.

Popular.

Schmidt, M.
Die Massnahmen zur Vermeidung der Kraüselkrankheit der Futter-und Zuckerrüben. D. Kurmärk. Bauer, 1934.

Schneider, G[eorge], Schlumberger, O[tto] & Snell, K[arl]
Versuchsergbnisse auf dem. Gesamtgebiete der Kartoffelbaus in den Jahren 1923–26. Nach. den Berichten der Kartoffelversuchastelden bearbeitet. Mitt. Biol. Reindsanstalt. f. Land-u. Forstwirtschaft **36**: 125, 1928.

Studies on mosaic.

Schreven, D. A. van
(The yellowing disease of sugar beets and its cause.) Meded. Inst. Suikerbieten. **6**(1) : 36, 1936.

This is a brief review of the most important chlorotic diseases of sugar beets in Europe and includes both virus and physiological diseases.

Schultz, E[ugene] S[chultz] et al.
Degeneration diseases of potatoes. Maine Agric. Expt. Sta. Bull. **377**: 348–350, 1934.

————————, et al.
Nature of virus diseases. Maine Agric. Expt. Sta. (Prog. Rpt.) Bull. **380**: 162, 1935.

————————, et al.
Comparison of two aphids species regarding transmission of mild mosaic, leaf roll and spindle tuber. Maine Agric. Expt. Sta. Bull. (Prog. Rpt.) **380**: 168–170, 1935.

————————, & Raleigh, W[alter] P[atrick]
Acquired resistance of potato to latent mosaic. Phytopathology (Abstract) **26**(2) : 107, 1936.

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Reaction of Green mountain potato seedling to composite infection of a mild and crinkle mosaic and different types of latent mosaic virus. Phytopathology (Abstract) **26**(2) : 107, 1936.

————————, & **Clark, C. F., Stevenson F. J., & Raleigh, W[alter] P[atrick]**

Resistant of the potato latent mosaic. Amer. Potato Journ. **14** (4): 124–127, 1937.

The results of some cross breeding.

————————, **Raleigh, W[alter] P[atrick], Stevenson, F. J., Bonde, Reiner & Beaumont, J. H.**

Recent developments in potato breeding for resistance to virus diseases. Phytopathology **27**(2): 190–197, 1937.

A record of very important studies on mild mosaic, veinbanding mosaic, spindle tuber and leaf roll.

Schuster, L.

Ein gefährlicher Zuckerrüben-schädling. Naturforschr **12**(12): 415–416, 1936.

The author believes that the beet leaf bug *Piesma quadrata (Zosmenus quadratus)* is the vector of crinkle.

Schwartze, C. D., & Huber, Glen A.

Aphis resistance in breeding mosaic-escaping red raspberries. Science **86**(2224): 158–159, 1934.

The author concludes by saying that resistance probably results from a lack of suitable food for the insect rather than the presence of an active repellent substance.

Schwirzer, J.

Tjemara-ziekte bij tabak. Besvekisch Proefstat. Meded. No. **50**: 1–28, 1933.

Scott, G. T.

New curly-top resistant strains of beets. West. Irrig. (San Francisco) **18**(2): 7, 1933. (Facts About Sugar (Abstract) **31**: 151, 1936.)

Popular.

Seastone, C. V., Loring, H. S., & Chester, K[enneth] S[tarr]

Anaphylaxis with tobacco mosaic virus protein and haemocyanin. Journ. Immunol. **33**(5): 407–418, 1937.

The results of these studies are summarized as follows: "The anaphylactic properties of the tobacco mosaic virus protein and the hemocyanin of *Limulus polyphemus* have been studied in sensitized guinea pigs *in vivo* and by means of the Schultz-Dale method."

The results demonstrate that the tobacco mosaic virus protein is anaphylactogenic when tested *in vivo,* but in agreement with previously published data fails to cause smooth muscle contraction when tested *in vitro.*

The results of the experiments with the hemocyanin of *Limulus polyphemus* demonstrate that his protein is anaphylactogenic when tested by either of the above methods.

Sesa, S. V.
Scheme for research on mosaic and other diseases of sugar cane. Scient. Rpt. Agric. Res. Inst. (Pusa) **1933–34**: 154–167, 1936.

Severin, H[enry] H[erman] P[aul], & Freitag, Julius H[erman]
Ornamental flowering plants naturally infected with curly-top and aster yellows viruses. Hilgardia **8**(8) : 223–260, 1934.

Fourteen species of ornamental plants in 13 genera belonging to 10 families have been found to be naturally infected with curly top in California.''

Shapovalov, M[ichael], & Dufrénoy, J[ean]
Un virus infectant des solanées et des plantes d'ornament dans le sud-ouest de la France. (A virus infectious to the ornamental Solanaceous plants of South West France.) Compt. Rend. Soc. Biol. (Paris) **123**(31) : 696–698.

This disease attacks *Lycopersicon esculentum, Nicotiana tabacum, Dahlia* sp. and *Callistephus sinensis.* It is transmitted by *Thrips tabaci.*

Shatova, E., & Krivin, B.
(The elaboration of methods of virological plant examination.) Summ. Sci. Res. Work Inst. Plant Prot. 1935, Leningrad, p. 507–509, 1936.

Sheffield, Frances M[arion] L[ena]
The susceptibility of the plant cell to virus diseases. Ann. Appl. Biol. **23**(3) : 498–505, 1936.

The author used aucuba mosaic (yellows strain) of tomato and tobacco mosaic (Johnson's No. 1) as the viruses. The host plants were *Solanum nodiflorum, S. lycopersicum, Nicotiana tabacum* and *N. glutinosa.* His results are summarized as follows: ''A number of spraying experiments showed that the virus cannot enter a plant unless some of the cells are injured. It is not essential that such injury should be brought about in the presence of the virus. The chances of infection fall off rapidly in the first few minutes after injury, but infection occurs occasionally as long as half an hour after this damage. ''Inoculations by micropipette into single cells of the hosts plant yielded only about one-tenth of the expected number of infections. This suggests differences in the susceptibility of the cells to virus attack.''

The role of plasmoderms in the translocation of virus. Ann. Appl. Biol. **23**(3) : 506–508, 1936.

The intracellular inclusions may occur in all the epidermal cells of a large area except in the guard cells. No protoplasmic connections could be shown between the guard and other epidermal cells. Therefore, the author suggests that the virus is carried from cell to cell by the protoplasmic bridges but cannot enter the guard cells because there are no protoplasmic connections.

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The histology of the necrotic lesions induced by virus diseases. Ann. Appl. Biol. **23**(4): 752–758, 1936.

The author stimulated mitosis in *Nicotiana glutinosa* by inoculation with aucuba mosaic. He describes the necrosis which follows the nuclear divisions.

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Intracellular inclusions in plant virus diseases. Deux. Cong. Int. Biol. **23**(3): 506–508, 1936.

Shen, C. I.
Studies in tomosis of cotton. Sinensia, Wanking **7**(3): 293–316, 1936.

Silberschmidt, Karl
O mosaico do fumo. (Tobacco mosaic.) O Biologico (Brazil) **2**(11): 381–383, 1936.

Brief popular notes describing the disease.

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A degenereschenoia da batatinha. (Potato degeneration.) O Biologico **3**(9): 247–254, 1937.

Popular discussion of the subject. In his statement the author attributes degeneration of potato to virus disease. He discusses several of the different types of potato virus diseases.

Simmonds, J[ohn] H[oward]
Diseases of the tomato. (Queensland Agric. Journ. **45**(1): 5–11, 1936.

Popular. Contains notes on mosaic, spotted wilt, big bud and streak.

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Les maladies du bananier. (Banana diseases.) Rev. Bot. Appl. & d'Agric. Tropic. **16**: 296–301, 1936.

Simpson, G[eddes] W.
Insects in relation to the transmission of virus diseases of potatoes. Maine Agric. Expt. Sta. Bull. **377**: 351–353, 1934.

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Insects in relation to the transmission of virus diseases. Maine Agric. Expt. Sta. Bull. **384**: 427–428, 1936.

A report of progress.

Skuderna, A. W.
Effects of time of planting and of fertilizer mixtures on the curly top resistant sugar beet variety U. S. No. 1 in Idaro. U.S.D.A. Circ. **273**, 15 p., 1933.

Small, C. G.
Spotted wilt (virus) in New York. U.S.D.A. Plant Diseases Rept. **20**(14): 226, 1936.

Small, T.
"Little potato" disease. Gard. Chron. **96**: 128, 1934.

Popular.

Smith, A. M., & Paterson, W. Y.
The study of variety and virus diseases of infection in tubers of *Solanum tuberosum* by the ascorbic acid test. Biochem. Journ. **31** (11) : 1992–1999, 1937.

Smith, Floyd F[ranklin]
The need of permanent reference collections of insect vectors of plant diseases. Phytopathology **27** (2) : 198–202, 1937.

A discussion of the importance of collections of insect vectors and more accurate data concerning them, about one-half this paper is devoted to the vectors of virus diseases.

Smith, J[ohn] Henderson
Discussion of recent work on heavy proteins in virus infection and its bearing on the nature of viruses. Proc. Royal Soc. Med. **31**: 199–210, 1938.

A review of our knowledge of crystals in relation to viruses.

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Some recent development in virus research. Ann. Appl. Biol. **25** (2) : 227–243, 1938.

This paper is the address of the retiring president of the Association of Applied Biologist delivered to the annual general meeting on Friday, February 11, 1938. It is a discussion of (1) methods of control and (2) nature of the virus. The second part is devoted primarily to the works of Stanley, Bawden and Pirie.

Smith, K[enneth] M[andly]
Mosaic disease. Gard. Chron. **73**: 345, 1923.

An editorial based on investigations on tomato mosaic.

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Mechanism of transmission of plant viruses. Proc. Roy. Soc. B. **112**, 1933.

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Plant viruses and their insect vectors. Fourth Imp. Ent. Conf. Rpt. p. 68–70, 1935.

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The problem of a plant virus infection. Second Int. Congr. Micro-Biol. London, 1936.

————————, **& Doncaster, J. P.**
The particles size of plant viruses. Third Int. Congr. Compar. Path. Rpt. **1** (2) : 179–182, 1936.

The determination of the particle size of a number of viruses by Elford's methods.

————————— An air-borne plant virus. Nature **139**(3513): 370, 1937.

This virus was obtained by drawing air through cotton wool pads. It was treated on leaves of *Phaseolus vulgaris*.

————————— Studies on a virus found in the roots of certain normal-looking plants. Parasitology **29**(1): 70–85, 1937.

A virus was found in the roots of several species of hosts plants which did not show symptoms of disease. *Nicotiana tabacum* and *N. glutinosa* sometimes showed symptoms, usually on the lower leaves. There was no evidence that the virus was carried in the seeds. The plants were grown in sterilized soil. The virus was never completely systemic in any host plants. The thermal death point is 72°C.

————————— Further studies on a virus found in the roots of certain normal-looking plants. Parasitology **29**(1): 86–87, 1937.

This is a record of a continuation of the studies recorded in the preceding papers. The virus was found to be a contamination from outside sources. It was found in the sludge at the bottom of the water tanks and the evidence shows that it was conveyed in the water to the soil and thence to the roots. It is thought to be a transitional stage between a pathogen and a non-pathogen.

————————— A textbook of plant virus diseases. A book of 615 p., 1937.

A very complete study. One section is devoted to insect vectors.

Snell, K[arl]
Untersuchungen über die Lupinen-brane (Viruskrankheiten.) (Investigation on Lupin virus diseases.) Nachrichtenbl. f. d. Deutsch. Pflanzenschutz. **15**(10): 90–91, 1935.

Snyder, W[illiam] C[owperthwaite], & Thomas, H. Rex
Spotted wilt of the sweet pea. Hilgardia **10**(8): 257–262, 1936.

This disease is described as streak. Results of experimental inoculations and a general discussion are given.

Sorauer, Paul C[arl Moritz]
Handbuch der Pflanzenkrankheiten. Erster Band. Die Nichtparasitaren und Viruskrankheiten. Zweiter Teil. Sechste, Nenbearbeitete Auflage. VIII: 553 p., 1934.

Soriano S.
Enfermedades de "virus" de las vegetales (Plant "virus" disease.) Rev. Centro Estud. Agron. Univ. Buenos Aires **24** (144): 207–237, 1931.

A popular account.

Spencer, Ernest L.

Influence of host nutrition systemic development of tobacco mosaic. Plant Physiology **12**(3): 825–832, 1937.

Nicotiana tabacum L. was grown in sand cultures for this work. The plants were inoculated with a yellow strain of tobacco mosaic. The influence of nutrition was measured by the time required for the virus to reach and produce symptoms in the apical leaves.

Symptoms appeared earlier in plants that had received a minimum or excess of nitrogen than in those that had received a medium amount.

Symptoms appeared earlier in plants that had not received phosphorus than in those that had received an excess for one week before inoculation. These plants showed symptoms earlier than those that had received an excess for 2, 3 or 4 weeks before inoculation.

The appearance of symptoms was correlated with excess of potassium.

"It is concluded that the systemic development of the disease was accelerated by high-nitrogen nutrition and retarded by either high-phosphorus or high-potassium nutrition. The rapidity with which symptoms of systemic infection developed showed no apparent correlation with the distance the virus had to travel to reach the growing tip."

Seasonal variations in susceptibility of tobacco to infection with tobacco-mosaic virus. Phytopathology **28**(2): 147–150, 1938.

The author summarizes the results of his studies as follows: "A study involving weekly tests over a period of 2½ years showed definite variations in the susceptibility of small Turkish tobacco plants to infection with tobacco-mosaic virus. Susceptibility was high during early summer, a period characterized by high temperature and long duration of sunshine, and low during late winter and early spring. The incubation period of the disease within the plant showed a direct correlation with seasonal fluctuations in light and temperature, being short during early summer and long during the winter months."

Spieckermann, A[lbert]

Wie schütze ich mich gegen den Abbau der Kartoffeln? Wochenbl. Landesbauernsch. Westf. 1239, 1935.

Spierenburg, Dina

Een Virusziekte in Lupinen. (A virus disease of lupines.) Tijdschr. Plantenziekten **42**(3): 71–76, 1936.

A disease causing dark stripes and spots on the stems. The leaves become violet-brown, wrinkled and the tops die.

Een Virusziekten in Lupinen. (A virus disease of lupines.) Tijdschir. Plantenz. **42**(9): 253–254, 1936.

Continuation of previous observations.

Spinks, G. T., & Glothier, C. E.

The incidence of "reversion" in seedling black currants and in sciones derived from them. Agric. & Hort. Res. Sta. Univ. of Bristol. Rpt. **1935**: 58–66, 1936.

Studies were made on 2,500 seedlings. Reversion was found on a few four year old plants but the majority remained healthy for six years. Some remained healthy for ten years. Systematic roguing gave good results but did not eliminate the disease. It is believed that in some cases the disease was latent for two years. There was no correlation of occurrence between reversion and big bud.

Sreenivasaya, M[ontnahalli]

Infectivity of various tissues of "spiked" sandal and studies in the resistance of sandal to "spike" disease Part. I. Ind. Sci. Cong. Proc. (Calcuta) **17**: 313, 1930.

Stanley, W[endell] M[eredith]

(Chemical studies on the virus of tobacco mosaic. VII—An improved method for the preparation of crystalline tobacco mosaic-virus protein. Journ. Biol. Chem. **115**(3) : 677–678, 1936.

This is a description of a method in which the author used ammonium sulfate, celite and calcium oxide. The yield of the crude twice precipitated globulum was increased to about 80 percent.

Krystallinziertes Tabakmosaikvirus-Protein. (Crystalline tobacco-mosaic virus protein.) Chemiker-Zetg. **60**: 778, 1936.

A note.

Crystalline tobacco-mosaic virus protein. Amer. Journ. Bot. **24**(2) : 59–68, 1937.

This is a summary and discussion of all the work of the author on this subject. The virus is protein in nature; the size of the molecule lies between the previously recorded values for tobacco mosaic virus. This crystalline protein could not be found in normal plants. The product from Burley tobacco in England is the same as the author found in the United States. It is possible that this protein may be inert and the carrier of the very small amount of an active virus agent. As a result of these studies it appear possible that protein molecules may be listed with living organisms.

A comparative study of some effects of several different viruses on Turkish tobacco plants. Phytopathology **27**(12) : 1152–1160, 1937.

The author summarizes his results as follows: "Tobacco-mosaic, aucuba-mosaic, masked-tobacco-mosaic, green- or yellow cucumber-mosaic, severe-etch, tobacco-ring-spot, and latent-mosaic viruses, when inoculated to small, medium-size, or large Turkish tobacco plants, stunt the growth of the plants. Tobacco and aucuba-mosaic viruses stimulate protein me-

tabolism, however, so that, even though the growth of the plants is stunted, the total protein produced by the diseased plants is greater than that of normal plants. All of the other viruses studied caused a decrease in the total protein produced by the plants. Although severe symptoms and an increased protein content were characteristic of the tobacco and aucuba-mosaic diseases, there appeared, in general, to be no direct correlation between the protein content of the diseased plants and the severity of the disease symptoms. The first extracts of frozen macerated plants were found to contain from 80 to 90 per cent of the extractable protein nitrogen in the plants. The extracts of plants diseased with tobacco-or aucuba- mosaic viruses were found to contain 2 or 3 times more protein nitrogen than the extracts of normal plants. This increase in protein nitrogen was found to be due to the production in diseased plants of large amounts of high molecular weight virus protein. The relationship between virus protein and intracellular crystalline deposits is discussed.

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Isolation and properties of virus proteins. Ergebuirse Phys. Biol. Chem. Exp. Phar. **39**: 294–347, 1937.

A very thorough and comprehensive review of the subject including a discussion as to whether the viruses may be low types of living organisms.

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Some biochemical investigations on the crystalline tobacco-mosaic virus proteins. Amer. Phil. Soc. Proc. **77**(4): 447–453, 1937.

This paper is a summary of the biochemical and serological studies of virus proteins. He says: "It is felt that the results fully justify the conclusion, for the present at least that this unusual high molecular weight protein is actually tobacco-mosaic virus."

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Virus proteins. A new group of macromolecules. Journ. Phys. Chem. **42**(1): 55–70, 1937.

The author discusses the nature of viruses and gives the results of experimental studies. He says: "Despite its tremendous size, tobacco mosaic virus protein has many of the ordinary properties of molecules. In addition, however, it possesses virus properties which includes the ability to reproduce and to mutate specificity of action with respect to host, and the ability to induce immunity. Several virus proteins, some from other plant diseases and some from animal and bacterial diseases, some larger and some smaller than tobacco mosaic virus protein, have been isolated and are now under investigation in various laboratories. The virus proteins thus represent a new group of macromolecules which are considerably larger than those of any group of proteins hitherto described. Because of its tremendous size, the air-driven quantity centrifuge and the ultra-centrifuge are peculiarly adapted to the isolation and study of the virus proteins. Since the virus protein possesses virus activity and certain properties characteristics of organisms, as

well as the properties of molecules, any attempt at this time to classify them definitely as molecules or as organisms should be one solely of convenience. However, their characterization as molecules is providing a new experimental approach to the general problem of the nature of viruses.''

————— Chemical studies on the virus of tobacco mosaic. VIII—The isolation of a crystalline protein possessing the properties of aucuba mosaic virus. Journ. Biol. Chem. **117**(1): 325–340, 1937.

The author reports the isolation of a crystalline protein which has the properties of aucuba mosaic virus. Its activities are the same or very similar to the activities of tobacco mosaic-virus but the crystals are larger, the solutions more silky and opalescent and its solubility lower. He believes that two different strains of a virus give rise to two different proteins.

————— Chemical studies on virus of tobacco mosaic. IX—Correlation of virus activity and protein on centrifugation or protein from solution under various conditions. Journ. Biol. Chem. **117**(2): 755–770, 1937.

The results demonstrated that in solution at different hydrogen ion concentration and in the presence of other proteins the virus activity remains with the high molecular weight, protein and is evidence, therefore, that the virus activity is a specific property of the high molecular weight protein.''

————— Chemical studies on the virus of tobacco mosaic, X—The activity and yield of virus protein from plants diseased for different periods of time. Journ. Biol. Chem. **117**(1): 205–217, 1937.

These studies are summarized as follows: The increase of tobacco mosaic virus protein in Turkish tobacco plants has been determined by isolating the virus protein in plants diseased for different periods of time. The efficiency of the isolation technique was determined by isolating virus protein from artificially prepared mixtures containing known amounts of virus protein. It was found that about 40 per cent of the virus protein can be isolated from plants containing only about 1 part of virus protein per 100,000 parts of plant material. Virus protein in Turkish tobacco plants was found to increase from an estimated 10 mg. per gm. of plant material to about 3 mg. per gm. of plant material during the course of 5 weeks. Virus protein in inoculated leaves was estimated to increase over a million times during a 4 days period. Although the virus protein content was found to reach a maximum 5 weeks after inoculation, the rate of increase was found to be greatest during the first 3 weeks. The total nitrogen content of extracts of diseased plants was found to remain about constant over long periods of time, whereas the protein nitrogen content was found to increase and reach a maximum and then to decrease. The amount of low molecular weight protein was found to decrease as the amount of the virus pro-

tein increased. No significant difference was found in the virus activity of protein obtained from plants that had been infected for from 2 to 13 weeks, although that of protein obtained from plants infected for only 1 week was significantly less.

The inactivation of crystalline tobacco-mosaic virus protein. Science **83**(2165) : 626–627, 1936.

The author refers to his previous work and says: "It has now been found that treatment of this active protein with hydrogen peroxide, formaldehyde, nitrous acid or ultra-violet light produces inactive native proteins that, although slightly altered, retain certain chemical and serological properties characteristic of the virus protein."

He follows a description of these studies with this statements: "As a whole, the preliminary results indicate that only slight changes occur in the protein molecules on inactivation by the four methods mentioned. Although there is always a possibility, as with any apparently pure substance, that the crystalline tobacco mosaic virus protein may consist of two closely related components, one active and the other inactive, the available evidence indicates that the virus activity is a specific property of this high molecular weight protein. It appears likely, therefore, that the slight changes in the protein, which result from treatment with formaldehyde, hydrogen peroxide, nitrous acid or ultraviolet light, cause it to loose its ability to infect susceptible plants."

Some biochemical investigations on the crystalline tobacco-mosaic virus proteins. Proc. Amer. Phytopathological Soc. (Abstract) **77**(4) : 447–453, 1937.

------------, & **Wyckoff, Ralph W[alter] G[raystone]**
The isolation of tobacco ring spot and other virus proteins by ultracentrifugation. Science **85**(2198) : 181–183, 1937.

The authors report the isolation of a high molecular weight crystalline protein, possessing properties of ring spot virus but different from tobacco mosaic virus protein. They used the ultracentrifuge method.

Stevens, N[eil] E[verett]
More about false blosson. Nat. Cranberry Mag. **2**(12) : 5–6, 1938.

Stevenson, J[ohn] A[lbert]
Further notes on the distribution of the witches' broom of black locust. U.S.D.A. Plant Disease Rept. **22**(9) : 148, 1938.

Stoddard, E. M.
Progress report of the "X" disease of peach. Proc. Connecticut Pomol. Soc. **45** : 25–27, 1935.

Appears to be a new virus disease.

Stone, Winona E[myle]

Growth, chemical composition, and efficiency of normal and mosaic potato plants in the field. Journ. Agric. Res. **52**(4): 295–309, 1936.

Mosaic potato plants lengthen more slowly and produce more leaves of less surface than normal plants. The total leaf surface is greater in the normal plants. The green weight per area is less in diseased than in normal plants, but the dry weight in diseased plants was greater per unit area than in the normal plants.

Storey, H[arold] H[aydon]

Report of the Plant Pathologist. East Afric. Agric. Res. Sta. Ann. Rpt. **1935**: 11–14, 1936.

The author reports two types of cassava mosaic, severe yellow mosaic, and extreme leaf distortion.

Virus diseases of East African Plants. IV–VI. East African Agric. Journ. **1**(4): 333–337 (6): 471–475, 1936. **2**(1): 34–39, 1936.

A continuation of a series of popular papers. Popular discussion of streak of maize and diseases of cassava.

A new virus of maize transmitted by *Cicadulina* sp. Ann. Appl. Biol. **24**(1): 87–94, 1937.

A description of a new disease which is transmitted by *Cicadulina mbila.*

Stubbs, M[erl] W.

Viroses of the garden pea, *Pisum sativum.* Phytopathology (Abstract) **26**(1): 108–109, 1936.

Certain viroses of the garden pea (*Pisum sativum*). Phytopathology **27**(3): 242–267, 1937.

A study of pea-mosaic viruses and tobacco ring spot virus. One mosaic virus was found to be distinct and designated as pea virus I. It causes enation pea mosaic. Three other pea mosaic viruses were found to be strains of a single virus and designated as pea virus-2. A causing marble pea mosaic, pea virus 2-B causing speckle pea mosaic and pea virus 2-C causing mild pea mosaic. Tobacco ring spot virus was also described. All the pea-mosaic viruses studied were transmitted by *Macrosiphum pisi* and by extracted juice when carborundrum was used for making the inoculations. 34 varieties of peas were found to be more or less susceptible to pea virus 1 and tobacco ring spot virus. Six varieties were not susceptible to the strains of pea virus 2. Pea virus I was inactivated by a dilution of 1 to 300 and 4 days aging *in vitro.* Peas and sweet peas were reported as new hosts of tobacco ring-spot virus. It is probable that pea mosaic may be caused by other viruses.

Subrahmanyan, V.

Investigations on the spike disease of sandal I–IV. Bangalor, 1931–32. Indian Inst. Sci. 1933.

Summers, E[aton] M[elroy]

An investigation of types or strains of the mosaic virus of sugar cane in Louisiana. Iowa State Journ. Sci. **11**(1): 118–120, 1936.

The author refers to four strains previously described and then gives evidence indicating the existence of other strains. (This paper is an abstract of a doctorate thesis.)

Swarbrick, T., & Thompson, C. R.

Observations upon the incidence of "Reversion" and the control of "Big Bud" in Black Currants. Long Ashton Res. Sta. Ann. Rpt. 1931, p. 101, 1931.

————, & Berry, W. E.

Further observations on the incidence and spread of reversion and big bud in black currants. Univ. Bristol Ann. Rpt. Agric. & Hort. Res. Sta. p. 124–232, 1936.

A study of the spread of the disease. The evidence indicates that the big bud mite is an important factor but there may be other agencies.

Swartele, A. A.

Bestaat or een verband turechen het voorkomen van "black heart" en het obtreden van virusziekten bij den aardappel? (Does a causal relation exist between the occurrence of black heart, and of virus diseases of the potato?) Plantenziekten **42**(9): 241–252, 1936.

The author has not been able to detect any relation between black heart and virus diseases.

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Onderzoek van Ziekteverschijnselen bij Fragaria. (Research work on degeneration diseases of strawberries.) Agriculture (Louvain) **41**(1): 1–10, 1938.

Takahashi, William N[oboru], & Rawlins T[homas] E[lsworth]

Stream double refraction of preparations of crystalline tobacco-mosaic protein. Science **85**(2195): 103–104, 1937.

This is a continuation of previous work by these authors. They prepared protein according to Stanley's method and say: "If the crystal preparations are pure these results indicate that a significant portion of the virus in the crystals has become inactive during the purification process and that this inactivation is greatest in the "C" preparations."

Tasugi, H., & Ikeno S.

(On the mosaic disease of lilies.) Ann. Phytopath. Soc. Japan **3**: 91, 1934.

A note.

Taubenhaus, J[acob] J[oseph], & Alstatt, G[eorge] E.
Texas Agricultural Experiment Station Ann. Rpt. 49: 96, 1936.

A record of several new hosts for spotted wilt of tomato and curly top of sugar beet.

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Curly top of spinach in Texas. U.S.D.A. Plant Disease Rept. 21(1): 2, 1937.

This disease was very severe in five counties. The insect vector (*Eutettix tenellus*) was found.

Taylor, C. F.
The incidence of yellow dwarf in potato varieties. Amer. Potato Journ. 15(2): 37–40, 1938.

Taylor, G. G., & Chamberlain, E[dward] E[dinborough]
Spotted-wilt on tobacco. New Zealand Agric. Journ. 54(5): 278–283, 1937.

Teng, S. C.
The cyrtosis of cotton. Sinensia, Nanking 7(1): 63–79, 1936.

This disease which has been attributed to a virus is believed to be caused by a leafhopper (*Chlorita biguttula* Mats.)

Thilliard, R.
Bestrijding der krul-en kroepoek-ziekte van tabak. Meded. Proefst. Vorstenl. Tabak (Java) 78, 18 p., 1934.

Thomas, H[arvey] E[arl] & Hildebrand, F[rank] M[errill]
A virus disease of prune. Phytopathology 26(12): 1145–1148, 1936.

A description of a virus disease that appears to be new.

Apple mosaic. Hilgardia 10(14): 581–588, 1937.

It appears that an infectious variegation of apple foliage was reported from France by Vibert in 1835. The author describes the symptoms in California and reports transmission to several plants. Efforts to control by heat were partially successful.

Thornberry, H. H., Valleau, W[illiam] D[ornay], & Johnson, E[dward] M[arshall]
Inactivation of tobacco-mosaic virus in cured tobacco leaves by dry heat. Phytopathology 28(2): 129–134, 1938.

This is a study of the resistance of the yellow, green and burning strains of tobacco mosaic to heat. All three show a similarity in cured tobacco. At 70° C. all strains were infectious after treatment for 60 hours. The writers give much data with discussion and state that the virus is inactivated at 150° C. (302° F.) in 0.5 of an hour.

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Crystallization of tobacco-mosaic virus protein. Science **87** (2248): 91–92, 1938.

The author describes a method of crystallization and refers to the work of Bawden and Pirie in England and of Stanley in the United States. He also said: "Tobacco juice from healthy plants when treated in a similar manner failed to develop any evidence of crystalline protein. The precipitate that formed was composed of amorphous material as far as could be determined microscopically."

Thornton, J. K.
Key to virus and non-virus diseases of potatoes. Pennsylvania State Farmer n.s. **2**(9): 390–391, 1937.

Thung, T. H.
(Infective principle and plant cell in some virus diseases of the tobacco plants.) I. Handeling van het zesde Nederl. Ind. Natuurwetenschappelijk Congres, 22–26 September, 1931, Bandoeg, Java, 1931.

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(The curl and crinkle diseases of tobacco and causes of their dissemination.) Meded. Proefst. Vorstenl. Tabak, Java **72**: 51–52, 1931.

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Smetslof en plantencel bij enkole virusziekten vande tabakspeant. III. (Infective principle and plant cell in some virus diseases of the tobacco plant III.) Tijdschr. Plantenziekten **43**(1): 11–32, 1937.

The author treats of immunity studies in which he used the viruses of ordinary tobacco mosaic, white mosaic, severe mosaic, ring spot necrosis, Vorstenlanden distorting strain I and Hohher distorting strain. These studies indicated four types of antagonism: (*a*) equilibrium, (*b*) domination, (*c*) regulable equilibrium and (*d*) partial over-weighting.

Tims E[ugene] C[hapel], Mills, P[ercy] J[oseph], & Edgerton, C[laude] W[ilbur]
Studies on sugarcane mosaic in Louisiana. Louisiana Agric. Expt. Sta. Bull. **263**, 39 p., 1935.

Account of studies and observations of mosaic disease on different hosts are definite and constantly occur. These are being called the green or varieties. Two distinct mosaic types characterized by symptoms which mild mosaic and the yellow or severe mosaic. Losses in yield are given, being greater in the case of yellow mosaic.

Toit, P. J. du
Viruses. South African Journ. Sci. **32**: 696–705, 1935.

Tompkins, C[hristian] M[ilton]
A transmissible mosaic disease of cauliflower. Journ. Agric. Res. **55**(1): 33–46, 1937.

A description of a disease of a previously undescribed virus. The virus is transmitted by *Brevicoryne brassicae, Rhopalosiphum pseudo-*

brassicae and *Myzus persicae*. The virus will remain active *in vitro* for 14 to 15 days at 20°C. It is inactivated at about 75°C. The dilution of 1–2000 is active. It attacks many plants.

————————, **Gardner Max W[illiam], & Thomas, H. Rex.**
Black ring, a virosis of cabbage and other crucifers. Phytopathology (Abstract) **27**(9): 955–956, 1937.

A description of the disease. Transmitted by rubbing and by the green peach aphid. Inactivated by 59°C. for ten minutes and by 3 days at 22°C. and by dilution of 1 to 1,000. Attacks all commercial varieties of cabbage. Infections were obtained on rhubarb, *Chenopodium album*, *C. murale*, spinach, *Stellaria media*, *Brassica arvensis*, kale, brussels sprouts, cauliflower, broccoli, kohlrabi, rutabaga, turnip, wall flower, annual and Brompton stock, dames violet, Virginia stock, water cress, honesty, Chinese radish, Turkish and white Burley tobacco and *Nicotiana glutinosa*. It is similar to ring spot disease of cabbage described by K. M. Smith in England in 1935.

Topekha, E. F.
(The biochemistry of virus diseased potatoes.) Bull. Appl. Bot. Select. **3**(14): 53–67, 1936. (Ber. Wiss. Biol. (Abstract) **46**: 3–4, 216, 1937.)

Tower, J. D.
Sugar beet experiments, 1901. Michigan Agric. Expt. Sta. Bull. **197**: 138–140, 1902.

The disease referred to in this paper and supposed to be due to bacteria was probably a virus disease recently described by Coons and others as "savoy".

Trochain, J.
Les conditions de la végétation au Sénégal. Le "gana" de l'arachide. (Vegetation conditions in Senegal. The "gana" of the peanut.) Bull. Soc. Nat. d'Acclim. Paris. **81**(7): 302–312, 1934.

Trotter, A[lessandro]
Ulteriori osservazioni sulle "virosi" del *Cestrum parqui* L'Hér. (Further observations on virus diseases of *Cestrum parqui* L'Hér.) Ric. Assoc. Divulg. Fitopat. Camapia ed Mezzogiorus (Portici) **5**: 61–64, 1936. (R. Obs. Reg. Fitopat. Portici, 4 p., 1936.)

A confirmation of previous work on this disease on this host.

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Il "verderame" de tabacchi in cura. (Verderame of curing tobacco.) Boll. Tec. Tab. **33**(2): 67–72, 1936.

Description of a spotting in curing tobacco which is believed to be due to mosaic.

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La "maculazione ad anello" nelle foglie del tabacco. (Ring spot of tobacco leaves.) Boll. Tec. Tab. **34**(1) : 51–60, 1937.

The disease has been found in Scafati (Salermo), Italy. The author gives a review of the subject.

Troy, Zeliaette

Aster yellows and its control. Contr. Boyce Thompson Inst. **1**(28) : 262–266, 1935.

Tschernyschev, O.

(Prophylaxis and therapy in fighting virus diseases of potato.) Arb. Wiss. Forsch-Unst. Kart.—Wirtsh. Moscow **4**: 52–58, 1935.

Tucker, J.

The value of seed potato certification to the potato industry. Amer. Potato Journ. **14**(2) : 39–45, 1937.

Gives percentage on diseases including leafroll and mosaic.

Turner, A. D.

"Red plant" disease of strawberry. Serious problem in the South. Fruit Grower **55**(1436) : 971–972, 1923.

Popular.

Turner, W[illiam] F.

Phony peach disease control is promoted by destroying wild peach trees. U.S.D.A. Yearbook p. 275–277, 1935.

Valleau, W[illiam] D[ornay]

Do tobacco plants recover from, and develop immunity to ringspot? Kentucky Agric. Expt. Sta. Res. Bull. **360**: 181–191, 1935.

The author gives a review of the subject and the results of his own studies which lead him to differ in his opinion from other workers. His ideas are summarized by the following extract: "If a tobacco plant already affected by one strain of the tobacco mosaic virus fails to develop symptoms when inoculated with another strain, it can hardly be considered as evidence of an acquired immunity, but may simply be proof that cells already affected by this virus cannot be affected by more of the same kind of virus, even tho it is of another strain . . . . . It appears better, for the time being, to speak of protection afforded by one strain of virus against a more injurious strain, bearing in mind the practical application, rather than to speak of an acquired immunity in the sense in which this term is used in animal and human pathology."

————————
Localization and resistance to tobacco mosaic, in *Nicotiana*. Kentucky Agric. Expt. Sta. Res. Bull. **360**: 202–230, 1935.

The author gives the results of his studies with discussion and concludes: "Necrotic-spotting is therefore, merely an index to the degree of sensitivity of the plant to the virus. If the term "localization" is to be used, it should be reserved for particular instances of necrotic

spotting where the virus is confined or localized within the inoculated leaf, but should not be used as a term to indicate local necrotic spotting. With our present varieties of tobacco, localization cannot be expected to be of value in the control of tobacco mosaic, because the common strains of tobacco mosaic are non-necrotic-spotting strains. Two types of resistance to the tobacco-mosaic viruses may be recognized in *Nicotiana tabacum;* one in which certain strains of the virus are sometimes prevented from causing systemic infection by a high degree of sensitivity of invaded cells, with localization in inoculated leaves, and another of the type of resistance shown by Ambalema to non-necrotic strains of the virus, in which the virus is inhibited from entering the young tissues of the plant. Failure of the tobacco-mosaic virus to enter seeds may be the results of inability of the virus to invade meristematic tissue. The suggestion is made that plants which are most highly sensitive to a virus (necrotic-spotting species or varieties) are those in which the virus multiplies most rapidly (*N. glutinosa,* for instance), and those least sensitive are those in which the virus finds the poorest medium for multiplication (Ambalema, for example.) Transfer of resistance of Ambalema, either with or without necrotic spotting, to our tobaccos, should prove a satisfactory and practical solution of the tobacco-mosaic problem.''

-------------, & Johnson, E[dward] M[arshall]

Burning and non-burning strains of tobacco mosaic. Kentucky Agric. Expt. Sta. Res. Bull. **361**: 233–238, 1935.

These studies show that some strains of mosaic cause burning while others do not; that some varieties are more susceptible than others and that the number of burned leaves varied on different plants. The authors say: ''Mosaic burn is evidently an invasion symptom as it appears to be limited almost entirely to tissues young enough to be invaded rapidly by the virus, but does not occur on leaves which have completed growth at the time of inoculation or in leaves produced subsequently to the appearance of mosaic symptoms in the growing point. The leaves which burned were only partially developed at the time of inoculation but old enough so that mosaic patterns did not develop in them.''

-------------, & Johnson, E[dward] M[arshall]

Tobacco diseases. Kentucky Agric. Expt. Sta. Bull. **362**: 62, 1936.

Description of many virus diseases.

A mosaic disease of peach in Kentucky. U.S.D.A. Plant Disease Rept. **20**(12): 199, 1936.

A brief note recording this disease.

-------------, & Johnson, E[dward] M[arshall]

Tobacco mosaic source of infection and control. Kentucky Agric. Expt. Sta. Bull. **376**: 223–262, 1937.

The authors give a large amount of data showing that tobacco mosaic can be controled.

————————
Kentucky Agricultural Experiment Station Ann. Rpt. for the year 1936. Part I. **49**: 63, 1937.

This report contains records on tobacco mosaic and crossing of Ambalema with White Burley for the control of mosaic.

————————, & **Diachun, Stephen**
Tests of strains of tobacco mosaic virus with Chester's field test. U.S.D.A. Plant Disease Rept. **22**(5): 77–81, 1938.

The authors conclude by saying: "While this test gave positive results with most of the strains of tobacco mosaic tested, it cannot be considered as accurate a method for identifying viruses, which are now classed as common or ordinary field mosaic, as the drying test."

Varadaraja Iyengar, A. V.
Influence of spike disease on the mineral metabolism of sandal. Current Sci. **6**(6): 278–279, 1937.

The calcium content is less and the nitrogen greater in healthy than in diseased plants.

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Contributions to the study of spike disease of sandal (*Santalum album* Linn.) Part XVII. Some factors relating to the abnormal accumulation of carbohydrates in diseased tissues. Journ. Indian Inst. Sci. **20** A (1): 1–14, 1937.

A chemical study.

Vargas, M. J.
Informe del Profesor Carlos E. Chardon sobre el mosaico de la caña de azúcar. (Report of Prof. Carlos E. Chardon on sugar cane mosaic.) Agricultura (Bogotá) **9**(6): 107–120, 1937.

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El mosaico de la caña de azúcar. (Sugar cane mosaic.) Agricultura (Bogotá) **9**(6): 121–125, 1937.

Venkata Rao, M. G.
The role of undergrowth in the spread of spike disease of sandal. Mysore Sandal Spike Invest. Comm., Bull. **6**, 18 p., 1934.

Vidal, L. F.
El mosaico de la caña de azúcar. (Sugar cane mosaic). Rev. Agric. (Dominican Rep.) **28**(89): 55–58, (90): 133–135, (91): 189–195, 1937.

A report on the disease and the control by sanitation and resistant varieties.

Vigneaud, Vincent du
The prize paper and its author. Science **85**(2197): 132–133, 1937.

A brief review of Dr. W. M. Stanley's paper for which he was awarded the American Association for the Advancement of Science's prize. Also a brief sketch of Dr. Stanley's life.

Vinodradova, E. I.
Ozimais pshenitas "moskovskaia". Iaroviz. Zhurn. Biol. Razv. Rast. p. 25–30, 1936.

Vinson, C[arl] G[eorge]
Virus diseases of plants. Purification of the virus of mosaic disease of tobacco. Missouri Agric. Expt. Sta. Res. Bull. **237**, 16 p., 1936.

The author used about 12,000 plants in these studies. Precipitation of the virus was practically completed by concentrations of safranin. About 10 mg. of nitrogen was obtained from 500 cc of juice of mosaic of tobacco plants by the use of lead acetate. Practically no nitrogen was found in the juice of healthy plants.

Further work on purification of tobacco mosaic virus. Phytopathology (Abstract) **28**(1): 23, 1938.

Vohme, R. W.
Das Vorkommen von Virosen auf dem Dahlemer Versuchsfelde. (The occurrence of viruses in the Dahlem experimental fields.) Arb. Biol. Reichsanst. **21**(1): 1–58, 1934.

Vuillet, J. A.
Á propos de la rosette de l'arachide: controle des pucerons par les insects auxiliaires. (On peanut rosette: control of aphids by means of beneficial insects.) Rev. Bot. Appl. d'Agr. Trop. (Paris) Bull. **149**(14): 8–12, 1934.

Wada, E., & Fukana, H.
(On the difference of X-bodies in green and yellow mosaic of wheat. Agric. & Hort. (Japan) **9**(6): 1778, 1790, 1934.

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On the difference and discrimination of wheat mosaic in Japan. Journ. Imp. Agric. Expt. Sta. **3**(1): 93–128, 1937.

A report of studies in which they found green and yellow mosaic.

Wade, Carrol W.
Peach mosaic disease in Colorado. Journ. Econ. Ent. **30**(6): 902–904, 1937.

A brief description of the disease and methods of control.

Waldmann, O.
Filtrierbares Virus als Krankheitserreger bei Mensch, Tier und Pflanze. Chemiker-Zeitg. **60**: 824–825, 1936.

Walker, J[ohn] C[harles], & Larson, R. H.
Increasing importance of cabbage mosaic. Phytopathology **27**(2): 142, 1937.

The authors described the symptoms and discussed the importance of this disease.

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Soil temperature in relation to potato yellow dwarf. Phytopathology (Abstract) **28**(1) : 21, 1938.

Walton, C. L.
The control of aphids attacking sprouting potatoes. Journ. Min. Agric. **30** : 1–4, 1923.

Wardlaw, C. W., & McGuire, L. P.
Cultivation and diseases of the banana in Brazil. Trop. Agric. (Trinidad) **10**(7) : 192–197, (8) : 211–217, (9) : 255–259, 1933.
The authors describe a disease which has symptoms of a virus.

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Banana diseases VIII. Notes of various diseases occurring in Trinidad. Trop. Agric. (Trinidad) **11**(6) : 143–149, 1934.
Contains a description of a mottling disease which may be due to a virus.

————————
Diseases of the banana and the Manila hemp plant. A book of 615 p., 1937.
Contains descriptions of virus diseases.

Ware, R. B.
Peach yellows and litle peach. Connecticut Bd. Agric. Spec. Rpt. 1896.
At the time of this publication no author attributed this disturbance. to a virus.

Wartenberg, H[ans], Hey, A., & Tahsin, A.
Untersuchungen über die Azidität des Gewelbebreies der Kartoffelknolle. Die elektrometrische Pflanzgutwertbestimmung der Kartoffelknolle. II. Mitteilung. (Studies on the acidity of the tissue emulsion of the potato tuber. The electrometric determination of the seed value of the potato tuber. (Note II.) Arb. Biol. Reichsanst. Land-u. Forstu., Berl.-Dahl, **21** (4) : 499–516, 1936.

————————, **& Lindau, G.**
"Studien über die "Dehydrase-wirkungen" gesunder und abbaukranker Kartoffelknollen. (Studies on the "dehydrase reaction" of locality and degenerate potato tuber.) Phytopath. Zeitchr. **9**(3) : 297–324, 1936.
The juices of degenerated potatoes undergo a more rapid clarification when treated with methylene blue solution than the juice from healthy potatoes.

————————, **& Hey, A.**
Das Redoxpotential de Gewebebreies der Kartoffelknolle. Die elektrometrische Pflanzgutwertbestimmung der Kartoffelknolle III. Mitteilung. (The oxidation-reduction potential of the pulped tissue of the potato tuber. The electrometric determination of the seed value of the potato tuber. Note III.) Planta **25** : 258–281, 1936.

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Die elektrometrische Pflanzgutwertbestimmung der Kartoffelknolle IV. Mitteilung. Das Redoxpotetial der Gewebebreiaufschlämmung der Kartoffelknolle als Kennziffer des Abbauses. (The electrochemical determination of the seed value of the potato tuber. No. IV. The reduction-oxidation potential of the pulped tissue of the potato tuber as the coefficient of degeneration.) Phytopath. Zeitschr. **9**(6) : 531–569, 1936.

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Ueber die Pufferung der Pressäfte abbaukranker und gesunder Knollen der Kartoffel. (On the buffering of the expressed juices of degeneration-diseased and sound potato tubers.) Phytopath, Zeitschr. **10**(1) : 43–56, 1937.

A study of the electrometric method with juices.

————————, & **Klinkowski, M.**

Eine "Jodprobe" zur Pflanzgutwertbestimmung der Kartoffel, Vorläufige Mitteilung aus Untersuchugen. (An "iodine test" of the value of potatoes for seed. Preliminary note on the investigations.) Phytopath. Zeitschr. **10**(1) : 107–109, 1937.

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Probleme der Forschungen über den Abbau der Kartoffel. I. Pflanzzeit der Pflanzgutbaues und Pflanzgutwert der Ernte. (Problems involved in the investigation of degeneration of potato. I. Time of sowing in the production of seed material and the seed value of the crop.) Züchter **9**(2) : 35–40, 1937.

Experimental studies indicate that in Germany the degeneration (virus) increase until sometime in June and July. Planting after that show less infections.

Watson (Hamilton) M[arion] A.

Field experiments on the control of aphis-transmitted virus diseases of *Hyoscyamus niger*. Ann. Appl. Biol. **24**(3) : 557–573, 1937.

A solution of nicotine and soft soap was used. The best results were obtained by spraying at two weeks intervals. The percentage of infection was lower on the sprayed than on the unsprayed plots. There was no effect in yield on the first year growth but a 30 percent increase in the third crop of the second year.

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Further studies in the relationship between *Hyoscyamus* virus 3 and the aphid *Myzus persicae* (Sulz.) with special reference to the effects of fasting. Proc. Roy Soc. ser. B. **125**(838) : 144–170, 1938.

The percentage of infection by *Myzus persicae* was increased when the feeding on infected plants was preceeded by fasting. The efficiency of the vector was increased by one hour of fasting but increased by longer periods.

Factors affecting the amount of infection obtained by aphis transmission of the virus Hy. III. Phil. Trans. Roy. Soc. Biol. Sci. ser. B. **226**(540) : 457–489, 1936.

The author gives results of studies on a number of insects and time of feeding. *Myzus persicae* can infect two plants in succession without return to source of virus, but the number of second infections decreases rapidly and is negligible after one hour.

Weaver, T. C.

Recommends remedies to overcome chlorosis in roses. Flor. Rev. **88**(2012) : 9, 1936.

Popular.

Weij, H. G. van der

De bodem als infectiebron van Rotterdam B-ziekte. (The soil as a source of infection by Rotterdam B-disease.) Deli Proefst. Medan, Sumatra Vlugschr. **61**. 6 p., 1936.

This is a very severe disease and is transmitted by the hands of the laborers.

Ziekten der Tabak. Een Overzicht van den ziekten en plagen der Deli-Tabak in het jaar 1935. (Tobacco diseases. A survey of the diseases and pests of Deli Tobacco in the year 1935.) Deli Proefst. Sumatra Meded. ser. 2, **93** : 3–11, 1936.

This paper contains several notes on mosaic ("peh sim"), Rotterdam-B, "gilak," ring spot and "daoon lidah".

Weimer, J[ames] L[e Roy]

Alfalfa dwarf, a virus disease transmissible by grafting. Journ. Agric. Res. **53**(5) : 333–347, 1936.

The evidence in the paper indicates that this disease is due to a virus which can be transmitted by grafting but not by juice inoculation.

Effect of the dwarf disease on the alfalfa plant. Journ. Agric. Res. **55**(2) : 87–104, 1937.

The possibility of insect transmission of alfalfa dwarf. Phytopathology **27**(6) : 697–702, 1937.

The spread of the disease suggests insect transmission. Plants protected by cages did not contract the disease, while those growing outside did contract it. Several species of insects in cages did not transmit.

Wellington, R[ichard]

Red plants in strawberries. Gard. Chron. **67**(1744) : 269, 1920.

Popular.

Wellman, F. L.
Control of southern celery mosaic in Florida by removing weeds that serve as sources of mosaic infection. U.S.D.A. Tech. Bull. **548**, 16 p., 1937.

A brief but very complete discussion of this disease. A brief history, description, host plants, sources of infection, means of transmission and control.

Wenk, H.
Kartoffelzuchtungsfragen. I. Teils: Standenauslese und Pflanzgubau bei Kartoffeln. (Potato breeding questions. Part I. Hill selection methods and seed production in potatoes.) Prackt. Pflanzenb. **14**(1): 2–13, 1936.

The spread of virus diseases is believed to be influenced by the weather and varies with the abundance of the vector.

Went, J. C.
The influence of various chemicals on the inactivation of tobacco virus I. Phytopath. Zeitschr. **10**(5): 480–489, 1937.

Studies were made with copper sulphate mercuric chloride and silver nitrate. The inactivation depends on the dilution of the virus and time of exposure.

Wery, G.
Sur la mosaique, maladie de la canne a sucre. (Mosaic, a disease of the sugar cane.) Compt. Rend. Acad. Agric. France **17** (22): 739–743, 1931.

West, J.
Leaf curl of tobacco in Southern Nigeria. Trop. Agric. (Trinidad) **13**(9): 242–244, 1936.

This disease practically ruined the crop of Virginia tobacco in 1923. It is transmitted by *Bemisia* sp.

Wheeler, E. J.
Inoculation of potato seedlings with yellow dwarf virus. Amer. Potato Journ. **13**(8): 220–222, 1936.

The disease can be transmitted by grafting.

Whipple, Otis C.
Spotted wilt of garden pea. Phytopathology **26**(9): 918–920, 1936.

This disease was found on *Pisum sativum*. Inoculations into tobacco, tomato, aster, nasturtium, *Nicotiana glutinosa, Datura stramonium* and *Emilia saggitata* produced the same symptoms. *Thrips tabaci* proved to be a vector.

White, G. B.
Stigmonose a disease of fruits. Phytopathology **4**: 402, 1914.

White, Philip R.

Survival of isolated tomato roots at suboptimal and supraoptimal temperature. Plant Physiology **12**(3) : 771–776, 1937.

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Separation from yeast of materials essential for growth of excised tomato roots. Plant Physiology **12**(3) : 777–791, 1937.

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Amino acids in the nutrition of excised tomato roots. Plant Physiology **12**(3) : 793–802, 1937.

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Vitamin B_1 in the nutrition of excised tomato roots. Plant Physiology **12**(3) : 803–811, 1937.

All the above have a bearing on the growing of roots for virus.

Whitehead T[atham]

The virus problem in relation to seed potato production in North Wales. Sci. Hort. **5**: 39–46, 1937.

A study of potato production with reference to virus diseases and their transmission by *Myzus persicae.*

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Virus diseases of the potato. The carrier problem. Its relation to symtomatology and commercial potato growing. Ann. Appl. Biol. **24**(2) : 323–341, 1937.

A study of carriers and the segregation of viruses.

Wickens, G. M.

A new and serious disease of tobacco in S. Rhodesia. Rhodesia Agric. Journ. **35**(3) : 181–184, 1938.

A preliminary paper on a disease that is transmitted by *Myzus persicae.* It appears to be caused by a virus.

Wilhelm, A. F.

Die Gelbñeckigkeit des Spinats. (Spinach mosaic.) Obst-u Gemü seb. **81**: 56–58, 1935.

Wiles, D. R. D.

Report of Plant Disease Inspector for the year 1930–31. Barbados Dept. Sci. & Agric. Ann. Rpt. **1930–31**: 98–101, 1931.

Contains some data on sugar cane mosaic.

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Report of the Plant Disease Inspector. Barbados Agric. Journ. **6**(2) : 83–88, 1937.

A short discussion of sugar cane mosaic disease is included in this paper.

Will, J. McG.

Woodiness in passion vines. Queensland Agric. Journ. **47**(5) : 501–502, 1937.

Williams, P. H.

Some important diseases of glass house plants. Ann. Appl. Biol. **23**(1) : 189–192, 1936.

Winberg, O.

La pomme de terre et sa dégénérescence. (The potato and its degeneration.) Journ. Agric. Pract. n. s. **56**(2) : 396–398, 1931.

Wollner

Ursachen und Verhütung des Kartoffelabbaus. Wochenbl. Landesbaernsch. Hann **89**: 1674, 1936.

Abbau und Herkunftswert bei Pflanzkartoffeln. Mitt. Landwirtsch. **51**: 852–853, 1936.

Wood, E. J. F.

Some anatomical and cytological studies on Fiji disease of sugar cane. Proc. Roy. Soc. Victoria **49**(2) : 308–313, 1937.

Wyckoff, R[alph] W[alter] G[raystone]

Molecular sedimentation constants of tobacco mosaic virus proteins extracted from plants at intervals after inoculations. Journ. Biol. Chem. **112**(1) : 219–224, 1934.

Studies were made on the proteins isolated from tobacco plants which had been inoculated with ordinary mosaic virus for 1, 2, etc. up to 13 weeks.

-------------, **& Corey, Robert B.**

The ultracentrifugal crystallization of tobacco mosaic. Science **84**(2188) : 513, 1936.

The authors obtained a crystalline virus protein by ultracentrifuging the juice of tobacco plants affected with mosaic disease, which is indistinguishable from that obtained by the chemical methods.

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X-ray diffraction patterns of crystalline tobacco mosaic proteins. Journ. Biol. Chem. **116**(1) : 51–55, 1936.

The authors summarized their work in part as follows: "A series of X-rays powder diffraction photographs has been made of crystalline tobacco mosaic virus proteins . . . . . No difference could be found in the patterns of the proteins of the ordinary and aucuba strains of the disease. Neither was there any alteration in the X-ray photograph after nine successive recrystallizations. Tobacco mosaic virus protein completely inactivated by means of ultraviolet irradiation and subsequent crystallizations gave a photograph having principal diffraction lines that are the same as those of the active protein.

-------------, **& Stanley, W[endell] M[eredith]**

An ultracentrifugal analysis of the crystalline virus protein isolated from plants diseased with different strains of tobacco mosaic virus. Journ. Biol Chem. **117**(1) : 57–71, 1937.

The conclusion is as follows: "From these observations it is apparent that a crystalline virus protein can be obtained directly by ul-

tracentrifuging the juice of plants affected with the tobacco mosaic disease. The X-ray patterns of this crystalline material and of the protein prepared from the juice by chemical means are indistinguishable; the two substances must therefore, be substantially identical.

————————, & Lagsdin, J. B.
Improvements in the air-driven ultracentrifuge for molecule sedimentation. Rev. Sci. Instruments 8(3): 74–77, 1937.

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Quantity ultracentrifugation with intense fields. Science **85** (2207): 390–391, 1937.

A brief discussion of the apparatus and methods used in the concentration of virus.

————————
Méthode pour la préparation des proteines par l'ultracentrifugation. (Method for the preparation of proteins by ultracentrifugation.) Compt. Rend. Soc. Biol. (Paris) **125**(14): 3–7, 1937.

A description of the methods used in the study of tobacco mosaic virus. The author traces the developments in the study of the tobacco mosaic virus and gives some observations on the virus causing infectious papilloma of the rabbit.

————————
Die Isolierung Hochmolekularer eiweisstoffe mit Ultrazentriguge. (The isolation of high-molecular proteins with the centrifuge.) Naturwissenschaften **25**: 481–483, 1937.

A review of recent researches.

————————
An ultracentrifugal study of the pH stability of tobacco mosaic virus protein. Journ. Biol. Chem. **122**(1): 239–247, 1937.

The author summarizes the results of his work as follows: "An ultracentrifugal study has been made of the molecular stability of the tobacco mosaic virus protein in solutions at a series of pH value between 1.5 and 11. On the alkaline side of the isoelectric point the molecules of the protein remain unchanged for at least two months at pH up to 8. Decomposition has occurred at pH 9; it is more rapid as the pH is raised and is practically instantaneous at pH 11. The split-products are smaller in the more alkaline solutions. On the acid side molecular changes begin between pH 1.8 and 1.5; at pH 1.5 destruction is complete within a few hours.

The three virus protein samples used in these experiments were isolated by quantity ultracentrifugation and gave sharply sedimenting boundaries. One was double boundaried; the other two contained only one molecular component. Differences between these proteins were observed at pH values near the isoelectric point.

In so far as different experimental conditions permit comparisons to be made, the effect of pH on infectivity and molecular stability are parallel. This agrees with the assumption that infectivity is a property of the protein molecules.

The ultracentrifugal purification and study of macromolecular proteins. Science 86(2222): 92–95, 1937.

The ultracentrifuge gives us a better method of studying viruses than the salting out method. The author discusses this method and its relation to the study of viruses.

The ultracentrifugal study of virus proteins. Amer. Phil. Soc. Proc. 77(4): 455–462, 1937.

"An air ultracentrifuge has been developed which is giving twofold help in the study of viruses. (1) Analytical runs with it, besides furnishing a measure of the size of the virus molecules, can tell whether a preparation is pure and what may be the molecular weight of its impurities, whether a virus consists of one molecular species or a family of related proteins, etc. (2) Runs in which large volumes are ultracentrifuges in fields sufficiently great to sediment any of the known viruses provide the basis for a method of preparing pure virus proteins without having recourse to chemical treatment. This method opens up the way to the study of viruses which, unlike that of the tobacco-mosaic disease, are relatively unstable or present in only small amounts."

Youden, W. J.
Use of incomplete block replications in estimating tobacco-mosaic virus. Contr. Boyce Thompson Inst. 9(1): 41–48, 1937.

A modification of the incomplete block described by Yates has been devised, the configuration of which permits the construction of complete blocks of replicates without sacrificing the advantage of the incomplete blocks. The design has been used in studies of the infectivity of solutions of crystalline tobacco-mosaic virus on *Nicotiana glutinosa* plants. The requisite computations for the application of the analysis of variance of the data are given.

Dilution curve of tobacco mosaic virus. Contr. Boyce Thompson Inst. 9(1): 49–58, 1937.

Data for 20 dilution series of tobacco-mosaic virus are given and show that in the neighborhood of 0.1 mg. of virus protein per cc. the virus solutions may be diluted without a corresponding decrease in lesions produced on the leaves of *Nicotiana glutinosa*. There is considerable evidence that there may be an increase in infectivity after moderate dilution. This was found to hold for two different sources. The method of complete blocks made possible the comparison of solutions that differed but little in concentration since consistent dilution curves were obtained with only nine *N. glutinosa* plants using an arithmetical series of dilutions in place of the more common logarithmic series.

Zaleski, K., & Tychanicz, M.

Boklerie wewnetrzne ziemniaka i ich stosunek do chorób wirusowych ziemniakow. (The internal bacteria of potatoes and their relation to virus diseases of the potatoes.) Roczm. Nauk. Rolnicz. i Lesn **41**(2) : 392–396, 1937.

Zaumeyer, W[illiam] J., & Wade, B. L.

Pea mosaic and its relation to other legume mosaic virus. Journ. Agric. Res. **53**(3) : 161–185, 1936.

Cross inoculation studies show that this virus attacks *Trifolium pratense, T. repens, T. hybridum* and *Melilotus alba.* The disease is most severe at the margin of the fields which indicates transmission from other hosts. It is believed that the pea and red clover viruses are identical. Studies were made on the influence of environmental conditions and on susceptible and resistant varieties.

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Pea streak and its relationship to strains of alfalfa mosaic. Phytopathology (Abstract) **27**(2) : 144, 1937.

The author describes three strains of the virus.

\-\-\-\-\-\-\-\-\-\-\-\-\-, **& Wade, B. L.**

Varietal reaction of pea to pea-streak virus 1. Phytopathology **27**(10) : 1009–1013, 1937.

Forty-seven varieties were tested and found to be susceptible. The work was conducted in a greenhouse and over a period of two years.

Zeller, Samford M[yron], & Slate, G. L.

Occurrence of English mosaic on red raspberry in Oregon. U.S.D.A. Plant Disease Rept. **20**: 123–125, 1936.

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Dwarf disease of the loganberry. Better Fruit **32**(8) : 18, 1938.

Popular.

Zundel, G[eorge] L[orenzo Ingram]

Yellows on various plants. U.S.D.A. Plant Disease Rept. **13**: 174, 1929.

INDEX

AUTHORS' INDEX

SECOND SUPPLEMENT TO HOST INDEX OF VIRUS DISEASES OF PLANTS *

By MELVILLE T. COOK, *Plant Pathologist.*

AIZOACEAE

MOLLUGO VERTICILLATA

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

AMARANTHACEAE

AMARANTHUS GRAECIZANS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

AMARANTHUS HYBRIDUS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

CELOSIA ARGENTINA CRISTATA

Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

GOMPHRENA NITIDA

Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

AMARILIDACEAE

AMARYLIS BELLADONA

Spotted wilt of tomato. Taubenhaus, Texas. 1936.

APOCINACEAE

VINCA MINOR

Cucumber mosaic. Wellman. Florida. 1935.

ARACEAE

ZANTEDESCHIA ALBOMACULATA

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

ZANTEDESCHIA REHMANNI

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

BIGNONIACEAE

TABEBUIA PALLIDA

Witches' broom. Cook. Puerto Rico. 1936.

* Journal of Agriculture of the University of Puerto Rico. 19(3): 315–406, July, 1935. 20(3): 691–727, July, 1936.

BROMELIACEAE

ANANAS SATIVUS

Mosaic. Carter. Hawaii. 1937. Causes a yellow spot different from the yellow spot previously reported. Also attacks *Commelina nudiflora*.

CAMPANULACEAE

CAMPANULA PYRAMIDALIS

Lycopersicum virus 3.

LOBELIA INFLATA

Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

LOBELLA SPICATA

Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

LOBELIA SPLENDENS

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

LOBELIA sp.

Cucumber virus 1. Ainsworth. England. 1936.

CARYOPHYLLACEAE

CERASTIUM VULGATUM

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

STELLARIA MEDIA

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.
Black ring spot. See cabbage in Brassica.

CHENOPODIACEAE

BETA VULGARIS

Leaf curl or crinkle. Wille. Germany. 1928.

Savoy. Coons, Kotilla & Stewart. U. S. 1936. This appears to be the same as the disease reported by Arthur and Golden (Indiana) as a bacterial disease in 1892.

A new mosaic disease of cabbage. Larson & Walker. Wisconsin. 1937.

CHENOPODIUM ALBUM

Black ring spot. See cabbage in Brassica.
Tobacco virus 1. Holmes. New Jersey. 1937.

CHENOPODIUM AMBROSIOIDES

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

CHENOPODIUM MURALE

Black ring spot. See cabbage in Brassica.

SALSOLA PESTIFER

Curly top of sugar beet. Carter. California. 1934.

SARCOBATUS VERMICULATUS

Curly top of sugar beet. Carter. California. 1934.

SPINACIA OLERACEA

A new mosaic of cabbage. Larson & Walker. Wisconsin. N. 1937. Tobacco ring spot.

SPINACIA sp.

Black ring spot. See cabbage in Brassica.

NOTE: Spinach is a host for beet mosaic in Germany and America. (Boning 1927 and Hoggan 1933). *Chenopodium album, Amaranthus retroflexus & Sonchus arvensis* (Mouravieff *et al.,* 1930). *Chenopodium album* in England (K. M. Smith in England, 1934).

COMMELINIACEAE

COMMELINA NUDIFLORA

Mosaic. Carter. Hawaii. 1937. Also attacks *Ananas sativus.*

COMPOSITAE

AMBROSIA ARTEMISIFOLIA

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

BIDENS FRONDOSA

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

CALENDULA sp.

A new mosaic of cabbage. Larson & Walker. Wisconsin. N. 1937.

CALLISTEPHUS SINENSIS

A new virus disease. Shapovalov & Dufrenoy. France. 1936. Also attacks *Dahlia* sp. *Lycopersicon esculentum* and *Nicotiana tabacum.* Transmitted by *Thrips tabaci.*

DAHLIA sp.

A virus disease. Shapovalov & Dufrency. France. 1936. Also attacks *Callistephus sinensis, Lycopersicon esculentum* and *Nicotiana tabacum.* Transmitted by *Thrips tabaci.*

ERIGERON ANNUS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

ERIGERON CANADENSIS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

GALINSOGA PARVIFLORA
Tabacco mosaic virus 1. Holmes. New Jersey. 1937.

HELIANTHUS TUBEROSUS
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

HIERACIUM SCABRUM
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

LACTUCA sp.
Dot disease. Brandenburg, Germany. 1928.

LACTUCA CANADENSIS
Spotted wilt of tomato. Taubenhaus. Texas. 1936.

LACTUCA GRAMINIFOLIA
Spotted wilt of tomato. Taubenhaus. Texas. 1936.

LACTUCA SATIVA var. *longifolia*
Streak (spotted wilt) Snyder & Thomas. California. 1936. This is a combination of streak with pea virus 1 and pea virus 3.

SENECIO CRUENTUS
Spotted wilt of tomato. Taubenhaus. Texas. 1936. Also reported by K. M. Smith in England in same year.

ZINNIA sp.
Spotted wilt of tomato. Taubenhaus. Texas. 1936.
A new mosaic of cabbage. Larson & Walker. Wisconsin. N. 1937.

CONVOLVULACEAE

IPOMOEA BATATA
Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

IPOMOEA PANDURA
Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

IPOMOEA TRIFIDA
Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

CRUCIFERAE

BARBAREA VULGARIS
Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

BRASSICA sp.
A new mosaic of cabbage. Larson & Walker. Wisconsin. N. 1937. Black ring spot of cabbage. Tompkins, Gardner & Thomas. California. 1937. Similar to ring spot of cabbage

reported by K. M. Smith in England in 1935. Attacks all cabbages. Infections have been obtained on rhubarb, *Chenopodium album, C. murale,* spinach, *Stellaria media, Brassica arvensis,* kale, Brussels sprouts, cauliflower, broccoli, kohlrabi, rutabaga, turnip, wallflower, annual and Brompton stock, dame violet,, Virginia stock, water cress, honesty, Chinese radish, Turkish and white Burley tobacco and *Nicotiana gutinosa.*

A dangerous disease of turnip, rape and rutabaga, Kaufman. Germany. 1935. Transmitted by *Lygus pratensis.*

BRASSICA ADPRESSA

A new mosaic disease of cauliflower. Tompkins. California. 1937.

BRASSICA ALBA

A new virus disease of cauliflower. Tompkins. California. 1937.

BRASSICA ARVENSIS

Black ring spot. See cabbage.

A new mosaic disease of cauliflower. Tompkins. California. 1937.

BRASSICA CAMPESTRIS

A new mosaic disease of cauliflower. Tompkins. California. 1937.

BRASSICA ALBA, B. CERNUA, B. NAPOBRASSICA, B. NAPUS var. *chinensis,* B. NIGRA, B. OLERACEA var. *bullata,* B. TYPICA.

Mosaic. Chamberlain. New Zealand. 1936. No data to determine if this is the same as the mosaic in other parts of the world.

BRASSICA GEMMIFERA

Necrotic ring spot. California.

BRASSICA JUNCEA COSS

New mosaic disease of cauliflower. Tompkins. California. 1937.

BRASSICA NAPOBRASSICA

New virus disease (*chlorosis*). Kaufman. Germany. 1936. Transmitted by *Lygus pratensis.*

BRASSICA NAPUS

New virus disease. Kaufman. Germany. 1936. Transmitted by *Lygus pratensis.*

New mosaic disease of cauliflower. Tompkins. California. 1937.

BRASSICA NIGRA

New mosaic disease of cauliflower. Tompkins. California. 1937.

BRASSICA OLERACEAE (varieties *acephala, gemmifera, capitata, botrytis*)

New mosaic disease of cauliflower. Tompkins. California. 1937.

Cabbage ring spot. Smith. 1935.

BRASSICA OLERACEAE var. *botrytis* (broccoli & cauliflower).

Necrotic ring mosaic. California.

BRASSICA OLERACEA var. *capitata*

Necrotic ring mosaic. Mississippi and Texas.

BRASSICA PE-TSAI

New mosaic disease of cauliflower. Tompkins. California. 1937.

BRASSICA RAPA

New mosaic disease of cauliflower. Tompkins. California. 1937.

CAPSELLA BURSA-PASTORIS

New mosaic disease of cauliflower. Tompkins. California. 1937.

New mosaic disease of cabbage. Larsen & Walker. Wisconsin. N. 1937.

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

CHEIRANTHUS CHIERI

Cabbage ring spot virus.

NOTE: Ainsworth reports that the mosaic-colorations previously reported are due to a virus similar to the one reported by Hoggan and Johnson (Phytopathology 25: 640) and to one reported by K. M. Smith (Gardeners' Chronicle 98: 213 and Ann. Appl. Biol. 22: 239–242).

CHEIRANTHUS CHERI ♀ X ERYSIMUM CHEIRANTOIDES ♂).

Cabbage ring spot.

COCHLEARIA AMORACIA

Mosaic. Dana. Oregon. 1932.

An undifferentiated Crucifer virus.

HESPERIS MATRONALIS

A new mosaic of cabbage. Larsen & Walker. Wisconsin. N. 1937.

Cabbage ring spot virus 1. K. M. Smith. England. 1937.

IBERIS AMARA

New mosaic disease of cauliflower. Tompkins. California. 1937.

LEPIDIUM CAMPESTRIS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

New mosaic disease of cauliflower. Tompkins. California. 1937.

LUNARIA ANNUA

Mosaic. Ogilvie. England. 1931.

New mosaic of cauliflower. Tompkins. 1937.

Brassica virus 3. K. M. Smith. England. 1937.

Coarse mottle (Crucifer virus).

MATHIOLA BICORNIS

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

MATHIOLA INCANA

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

Cabbage ring spot virus 1. K. M. Smith. England. 1937.

Rosette virus 3. K. M. Smith. England. 1937.

A new mosaic of cabbage. Larsen & Walker. Wisconsin. N. 1937.

A new mosaic of cauliflower. Tompkins. California. 1937.

Stunting. Beet virus 1. K. M. Smith. England. 1937.

NASTURTIUM OFFICINALE

Cucumber mosaic virus 1. Ainsworth. England. 1935.

RADICULA PALUSTRIS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

RAPHANUS RAPHANISTRUM

New mosaic of cauliflower. Tompkins. California. 1937.

RAPHANUS SATIVUS CAUDATUS

Mosaic. Kulkarni. India. 1922.

SISYMBRIMUM ALTISSIMUM

Curly top of sugar beet. Carter. California. 1930.

SISYMBRIUM OFFICINALE

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

SISYMBRIUM THALINUM

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

SOPHIA FILIPES

Curly top of sugar beet. Carter. California. 1930.

SOPHIA SOPHIA

Curly top of sugar beet. Carter. California. 1930.

THLASPI ARVENSE

A new mosaic of cabbage. Larsen & Walker. Wisconsin. N. 1937.

CUCURBITACEAE

MICRAMPELIS LOBATA

Cucumber virus 1. Was reported without number by Doolittle 1925.

EUPHORBIACEA

EUPHORBIA PEPLUS

Mosaic. New South Wales. 1936.

MANIHOT UTILISSIMA

Stem lesion cause by Manihot virus 2.

PEDILANTHUS AUGUSTIFOLIUS

Specimens brought to the writer by Mr. J. I. Otero, September 21, 1936 showed symptoms of mosaic which were apparently due to a virus. Puerto Rico.

GERANIACEAE

GERANIUM CAROLINIANUM

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

PELARGONIUM DOMESTICUM

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

PELARGONIUM GRAVIOLENS

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

PELARGONIUM ZONALE

Mosaic. Jones. Washington State. N. 1937.
Crinkle. Jones. Washington State. N. 1937.

GRAMINEAE

AGROPYRON REPENS

Mosaic rosette of wheat. McKinney. Mississippi Valley. 1937.
Yellow mosaic of wheat. McKinney. Mississippi Valley. 1937.

SACCHARUM OFFICINARUM

NOTE: The following five diseases of minor importance which have been reported show some characteristics of virus diseases but it has not been proved that they are caused by viruses.

Leaf freckles. Priode. Cuba. 1929.
Lemon stripe. Priode. Cuba. 1928.
Spindle blotch. Faris. Cuba. 1927.
Spindle blotch. Faris. Cuba. 1927.
Gray stripe. Weir. Cuba. 1927.

TRITICUM AESTIVUM

Green mosaic rosette (virus 1). McKinney. Illinois. 1937.
Green mosaic (virus 2). McKinney. Virginia. 1937.
Yellow mosaic (virus 3). McKinney. Illinois. 1937.
Light green mosaic (virus 4). McKinney. Kansas. 1937.
Yellow mosaic (virus 5). McKinney. Kansas. 1937.
Mild streak (virus 6). McKinney. Kansas. 1937.
Yellow streak (virus 7). McKinney. Kansas. 1937.

TRITICUM sp.

Green and yellow mosaic. Wada & Fukana. Japan. 1937.

ZEA MAYS

New disease. Storey. South Africa. 1937. Transmitted by *Cicadulina mbila.*

IRIDACEAE

FREESIA sp.

Freesia mosaic.

IRIS RICHARDI

Mosaic. Brierley & McWhorter. Pacific Coast. 1936.

IRIS UNGUICULARIS ALBA

Mosaic. Brierley & McWhorter. Pacific Coast. 1936.

NARCISSUS spp.

Narcissus stripe (Tulip virus 1) Atanosoff. Bulgaria, 1928.

JUGLANDACEAE

HICORIA AQUATICA & H. PECAN

Bunch disease. Cole. Louisiana. 1936. May be a virus disease.

LABIATAE

HEDEOMA PULEGIODES

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

LAMIUN AMPLEXICAULE

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

PRUNELLA VULGARIS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

SALVIA sp.

Chlorosis. New South Wales. 1932.

LEGUMINOSAE

CICER ARIETIUM
Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

CROTALARIA INCANA
Mosaic. Virginia. Johnson & Lefebvre. N. 1937.

CROTALARIA INTERMEDIA
Mosaic. Virginia. Johnson & Lefebvre. N. 1937.

CROTALARIA LANCIOLATA
Mosaic. Virginia. Johnson & Lefebvre. N. 1937.

CROTALARIA MAXILLARIS
Mosaic. Virginia. Johnson & Lefebvre. N. 1937.

CROTALARIA RETUSA
Mosaic. Virginia. Johnson & Lefebvre. N. 1937.

CROTALARIA SPECTABILIS
Mosaic. Virginia. Johnson & Lefebvre. N. 1937.

CROTALARIA USARAMOENSIS
Mosaic. Virginia. Johnson & Lefebvre. N. 1937.

DESMODIUM CANADENSE
Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

GLEDITSIA TRIACATHUS
Witches' broom. Grant & Hartley. Ohio. 1938.

LATHYRUS LATIFOLIUS
Severe mosaic. Johnson & Jones. Washington State. 1937.
Enation mosaic. Johnson & Jones. Washington State. 1937.

LATHYRUS ODORATUS
Pea mosaic virus No. 2 from *Vicia faba* by *Macrosiphum pisi*. Osborn. New Jersey. 1937.
Streak (spotted wilt) Snyder & Thomas. California. 1936 Combinations of streak with pea virus 1 and pea virus 3.
Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.
Severe mosaic. Johnson & Jones. Washington State. 1937.
Enation mosaic. Johnson & Jones. Washington State. 1937.

LATHYRUS SATIVUS
Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

LENS ESCULENTA
Severe mosaic. Johnson & Jones. Washington State. 1937.
Pea virus 1 & 2 (strains 2–A, 2–B & 2–C). Stubbs. Wisconsin. 1937.

LUPINUS sp.

A virus disease. Spienrenburg. Germany. 1936.

A browning virus. Kohler. Germany. 1937. Same as Ainsworth's yellow mosaic of cucumber, Johnson's cucumber virus 1 and spinach mosaic.

LUPINUS ALBUS

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

LUPINUS ANGUSTIFOLIUS

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

Cucumber virus 1. K. M. Smith. England. 1937.

LUPINUS DENSIFLORUS

Pea mosaic virus. Murphy & Pierce. Idaho. 1937.

LUPINUS HARTWEGII

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

LUPINUS LEUCOPHYLLUS

Tomato spotted wilt virus 3. K. M. Smith. England. 1937.

LUPINUS NANUS

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

LUPINUS SUGARNOSUS

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

MEDICAGO ARABICA

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

Dwarf. Weimer. U. S. 1936. Transmitted by grafting but not by inoculation.

MEDICAGO HISPIDA

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

MEDICAGO LUPULINA

Severe mosaic. Johnson & Jones. Washington State. 1937.

MEDICAGO SATIVA

Severe mosaic. Johnson & Jones. Washington State. 1937.

Enation mosaic. Johnson & Jones. Washington State. 1937.

* Alfalfa virus 2. Pierce. Wisconsin. 1934.

* White clover mosaic virus 1. Pierce. Idaho. 1935.

Lucerne or alfalfa mosaic (Medicago virus 1).

MELILOTUS ALBA

Vein-mosaic. Osborn. New Jersey. 1937.

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

Pea mosaic virus No. 2 from *Vicia faba* by *Macrosiphum pisi.* Osborn. New Jersey. 1937.

MELILOTUS ALBA var. *annua*.

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

Pea mosaic virus 2 from *Vicia faba* by *Macrosiphum pisi*. Osborn. New Jersey. 1937.

MELILOTUS INDICA

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

MELILOTUS OFFICINALIS

Severe mosaic. Johnson & Jones. Washington State. 1937.

* Yellow bean mosaic virus 2. Pierce. Wisconsin. 1934. Idaho. 1935.

* Common pea mosaic virus 3. Pierce. Idaho. 1935.

* White clover mosaic virus 1. Pierce. Idaho. 1935.

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1934.

PHASEOLUS ACUTIFOLIUS var. *latifolius*

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1934.

One sided mosaic on refugee bean. Horsfall, Burkholder & Reinking. New York. 1937. This disease was mentioned by Harrison & Burkholder in 1936.

PHASEOLUS VULGARIS

Pea mosaic virus 2 from *Vicia faba* by *Macrosiphum pisi*. Osborn. New Jersey. 1937.

Dwarf. Harrison & Burkholder. New York. 1936. N.

Severe mosaic on several varieties. Johnson & Jones. Washington State. 1937.

Enation mosaic on Corbett refugee only. Johnson & Jones. Washington State. 1937.

* Common bean mosaic virus 1. Pierce. Wisconsin. 1934. Idaho. 1935.

* Yellow bean mosaic virus 2. Pierce. Wisconsin. 1934. Idaho. 1935.

* White clover mosaic virus 1. Pierce. Idaho. 1935.

* Tobacco mosaic virus 1. Pierce. Wisconsin. 1934.

* Tobacco ring spot virus. Pierce. Wisconsin. 1934.

NOTE: Corrections: Bean viruses Nos. 1 & 2, alfalfa virus No. 2 and tobacco ring spot virus which are credited to Price on page 703 of the second supplement should be credited to Pierce. Pea viruses Nos. 1 & 3, soy bean virus No. 1 and local lesion virus are not transmissible to *Phaseolus vulgaris*. They should be listed under *Pisum sativum*.

PISUM SATIVUM

Local lesion virus. Pierce. Idaho. 1934.

Streak (spotted wilt). Snyder & Thomas. California. 1936. N. This is a combination of streak with pea viruses 1 & 2.

Mosaic. Inoculated from *Trifolium pratense*, *T. repens*, *T. hybridum* and *Melilotus alba*. Zaumeyer & Wade. 1936.

Pea viruses 1 & 3. Pierce. Idaho. 1934.

Pea viruses 1 & 2 (strains 2–A, 2–B and 2–C). Wisconsin. 1937.

Pea mosaic virus No. 2 from *Vicia faba* by *Macrosiphum pisi.* Osborn. New Jersey. 1937.

Tobacco ringspot virus. Stubbs. Wisconsin. 1937.

Soy bean virus 1. Pierce. Idaho. 1934.

Enation pea mosaic virus 1. Pierce. Idaho. 1935.

* Enation pea mosaic virus. Johnson & Jones. Washington State. 1937. Similar to Zaumeyer & Wade's common pea mosaic but different in that it does not attack refugee bean.

* Common pea mosaic (pea virus 1). Pierce. Idaho. 1935.

* White clover virus. Pierce. Idaho. 1935.

* Broad bean local lesion virus. Idaho. Pierce. 1935.

Yellow bean virus 2. Pierce. Idaho. 1935.

Severe mosaic. Johnson & Jones. Washington. 1937. Similar to Zaumeyer & Wade's sweet clover mosaic.

Datura virus 1.

NOTE: Chamberlain (Australia 1937) reports that the pea mosaic of Australia is same as in U. S. That it attacks blue lupins, broad beans, sweet peas and garden peas. It is transmitted by *Myzus persicae*, *Aphis rumicis* and *Macrosiphum gei.*

SOJA MAX

* Soy bean mosaic virus 1. Pierce. Idaho. 1935.

* Enation pea mosaic virus 1. Pierce. Idaho. 1935.

* Broad local lesion virus.

Vein mosaic. Osborn. New Jersey. 1937.

TRIFOLIUM AGRARIUM

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

TRIFOLIUM CAROLINIANUM

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

TRIFOLIUM DUBIUM

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

TRIFOLIUM GLOMERATUM

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

TRIFOLIUM HYBRIDUM

Mosaic virus 1. Zaumeyer & Wade. U. S. 1936.

Severe mosaic. Johnson & Jones. Washington State. 1937.

Enation mosaic. Johnson & Jones. Washington State. 1937.

Vein mosaic. Osborn. New Jersey. 1937.

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

TRIFOLIUM INCARNATUM

Pea virus 2 from *Vicia faba* by *Macrosiphum pisi*. Osborn. New Jersey. 1937.

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

Vein mosaic. Osborn. New Jersey. 1937.

TRIFOLIUM PRATENSE

Pea virus 2 from *Vicia faba* by *Macrosiphum pisi*. Osborn. New Jersey. 1937.

Severe mosaic. Johnson & Jones. Washington State. 1937.

* Alfalfa virus 2. Pierce. Wisconsin. 1934.

* Common pea mosaic virus 3. Pierce. Idaho. 1935.

Yellow bean virus 2. Pierce. Idaho. 1935.

* White clover mosaic virus 1. Pierce. Idaho. 1935.

Vein mosaic. Osborn. New Jersey. 1937.

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

TRIFOLIUM PROCUMBENS

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

TRIFOLIUM REFLEXUM

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

TRIFOLIUM REPENS

White clover mosaic virus 1.

Tobacco ring spot.

* Alfalfa virus 2. Pierce. Wisconsin. 1934.

* White clover mosaic virus 1. Pierce. Idaho. 1935.

Severe mosaic. Johnson & Jones. Washington State. 1937.

Vein mosaic. Osborn. New Jersey. 1937.

TRIFOLIUM SUAVEOLENS

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

VICIA FABA

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

Severe mosaic. Johnson & Jones. Washington State. 1937.

Vein mosaic. Osborn. New Jersey. 1937.

VICIA FABA var. *minor*.

* Yellow bean mosaic virus 2. Pierce. Wisconsin. 1934. Idaho. 1935.

* Alfalfa virus 2. Pierce. Wisconsin. 1934.

* Tobacco ringspot virus. Pierce. Wisconsin. 1934.

* Common pea mosaic virus 3. Pierce. Idaho. 1935.

* Enation pea mosaic virus 1. Pierce. Idaho. 1935.

* White clover mosaic virus 1. Pierce. Idaho. 1935.

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

VICIA SATIVA

Severe mosaic. Johnson & Jones. Washington State. 1937.

Pea mosaic virus 3. Murphy & Pierce. Idaho. 1937.

* NOTE: Correction for error on page 703 of first supplement. Three records attributed to Price should have been credited to Pierce, who has given me his records in full. These records are marked in the preceding paragraphs with *

NOTE: The enation mosaic virus appears to be the same as common mosaic of Johnson & Jones, and of Osborn and similar to the one reported by Zaumeyer & Wade in 1936. It differs from the bean mosaic of Z. & W. (1935). The severe mosaic virus appears to be similar to that reported by Pierce (1935) and to that described by Z. & W. (1936) as pea virus 3.

LILIACEAE

FRITILLARIA CAMSCHATCENSIS

Green mosaic. Japan.

HYCINTHUS spp.

Hyacinth stripe, virus 1 (same as tulip virus).

LILIUM sp.

Crooked neck. Stout. New York. 1927.

Pimple leaf. Known by New York florists for many years.

LILIUM AURATIUM & var. *platyphyllum*

Green mosaic, yellow mosaic and crooked neck. Kawamura. Japan. 1938.

LILIUM CANDIDUM

Latent virus (same as tulip virus). McWhorter. Oregon. 1937.

LILIUM ELEGANS

Green mosaic. Kawamura. Japan. 1938. Also on several varieties.

Yellow mosaic. Kawamura. Japan. 1938. Also on variety *simiplenes*.

LILIUM LONGIFLORUM

Latent virus (same as tulip virus). McWhorter. Oregon. 1937.

LILIUM LONGIFLORUM FORMOSANUM

Green and yellow rosette and pimple leaf.

LILIUM LONGIFLORUM GIGANTIUM

Green and yellow rosette and pimple leaf.

LILIUM LONGIFOLIUS ALBOMARGINATUS and also var. *Togo*.

Yellow mosaic.

Green mosaic on varieties *Agata* and *Togo*.

LILIUM LEICHTLINII MAXIMOWICZII

Green mosaic.

LILIUM SPECIOSUM ALBUM

Green and yellow mosaic.

LILIUM SPECIOSUM RUBRUM

Green and yellow mosaic.

LILIUM SPECIOSUM KRAETZERI

Green mosaic.

LILIUM TIGRINUM

Latent virus (same as tulip virus). McWhorter. Oregon. 1937.

Tomato spotted wilt. New South Wales. 1936.

Green mosaic.

LILIUM TIGRINUM FORTUNEI

Green and yellow mosaic.

LILIUM UKEYURI

Green mosaic.

MALVACEAE

ABUTILUM ARBORUM
ABUTILON PATERSONI
ABUTIFOLIUM VITIFOLIUM
} Chlorosis. Lindemuth. 1872-78.

ABUTILON TONELIANUM

Variegations. Morrens. Mexico. 1869.

MORACEAE

HUMULUS LUPULUS

Fluffy tip or bunchy top. Salmon. England. 1936. Probably due to a virus.

NOTE: According to Salmon (1935) the definite virus diseases previously reported are nettlehead, mosaic, chlorotic disease.

Slip down. Magie. New York. 1937.

MORUS sp.

Mosaic. New Jersey. 1936.

MYRTACEAE

CHAMAELANCIUM UNCINATUM

Mosaic. New South Wales. 1935.

PAPAVERACEAE

CHELIDONIUM MAJUS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

PASSIFLORACEAE

PASSIFLORA sp.

Woodiness or bullet disease. New South Wales. 1928.

PASSIFLORA AURANTIA

Woodiness or bullet disease. New South Wales. 1928.

PASSIFLORA COERULEA

Woodiness or bullet disease. New South Wales. 1928.

PASSIFLORA HERTIANA

Woodiness or bullet disease. New South Wales. 1928.

PASSIFLORA INCARNATA

Woodiness or bullet disease. New South Wales. 1928.

PASSIFLORA LUTEA

Woodiness or bullet disease. New South Wales. 1928.

PASSIFLORA QUADRANGULARIS

Woodiness or bullet disease. New South Wales. 1928.

PASSIFLORA SUBEROSA

Woodiness or bullet disease. New South Wales. 1928.

TASONIA MOLLISIMA

Woodiness or bullet disease. New South Wales. 1928.

PHYTOLACCACEAE

PHYTOLACCA DECANDRA
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

PLANTAGINACEAE

PLANTAGO MAJOR
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

PLANTAGO REGELI
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

PLANTAGO LANCEOLATA
Tobacco mosaic virus 1. Holmes. New Brunswick. 1937.

POLYGONACEAE

FAGOPYRUM ESCULETUM
Stunting (cucumber virus 1) K. M. Smith. England. 1937.

POLYGONUM AVICULARE
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

POLYGONUM CONVOLVULUS
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

POLYGONUM ERECTUM
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

RHEUM sp.
Black ring spot. See cabbage in Brassica.

RUMEX sp.
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

RUMEX ACETOSELLA
Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

RUMEX SCUTATUS
Curly top of sugar beet.

PRIMULACEAE

PRIMULA ABCONIA
Cucumber virus 1. Ainsworth. England. 1936.

PRIMULA JAPONICA
Cucumber virus 1. Ainsworth. England. 1936.

RANUNCULACEAE

DELPHINIUM sp.
Witches' broom. Same as stunt. Stunt, dwarf and witches' broom are due to the same virus.

PAEONIA sp.
Ringspot. Green. England. 1935.

RANUNCULUS sp.
Yellows. New South Wales.

RANUNCULUS FASCICULARIS
Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

RANUNCULUS PUSILLUS
Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

RANUNCULUS SCLERATUS
Curly top of sugar beet. Taubenhaus. Texas. 1936.

ROSACEAE

COTONEASTER HARROVIANA
Mosaic of apple. See *Pyrus*.

ERIOBOTRYA JAPONICA
Mosaic of apple. See *Pyrus*.

FRAGARIA sp.
Mosaic. New South Wales. 1936.
Crinkle of strawberry. Wormald & Harris. England. 1936.

PHOTINIA ARBUTIFOLIA
Mosaic of apple. See *Pyrus*.

PRUNUS sp.
Mosaic of apricot, cherry, peach and plum reported by Atanasoff in 1934. Transmitted by *Anuraphis padi*.
Mosaic was believed to be the same as peach mosaic (but not proven) was reported on apricot, almond, prune, plum and Myrobalan plum in California by Cochran in 1937.
Apparently a new disease of prume. Thomas & Hildebrand. New York. 1936.

PRUNUS ALLEGHANIENSIS
Asteroid spot. Cochran & Smith. California. N. 1938.

PRUNUS ARMENIACA
Peach rosette. I.
Peach mosaic.

PRUNUS AMERICANA
Little peach. Manns. Delaware. 1936.
Peach yellows. Hartzell. New York. 1935.
Peach rosette. I.

PRUNUS COMMUNIS
Peach mosaic.
Peach yellows. Hartzell. New York. 1935.

PRUNUS DOMESTICUS
Little peach. Manns. Delaware. 1936.

PRUNUS DOMESTICUS var. *nucipersica*
Peach yellows. Hartzell. New York. 1935.

PRUNUS MYROBALAN
Yellows. Manns. Delaware. 1936.
Little peach. Manns. Delaware. 1936.

PRUNUS SALICINA
Peach yellows. Hartzell. New York. 1935.
Little peach. Manns. Delaware. 1936.

PYRUS sp.
Infectious variegations of apple foliage. Vibert. France. 1935.
Mosaic. Thomas. California. 1937. Reports that this disease is transmissible from *Pyrus malus* to *Coloneaster harreviana, Eriobotrya Japonica, Photinia arbutifolia* and in one case to *Sorbus pallescens.*

PYRUS AUCUPARIA
Variegations. Pyrus vrius 1. Atanosoff. Bulgaria. 1935.

PYRUS COMMUNIS
Apple mosaic (Pyrus virus 2).

PYRUS CYDONIA
Apple mosaic (Pyrus virus 2).

RUBUS ALLEGHENIENSIS
Mosaic (rare). Cooley. Western New York. 1936.
Streak. Cooley. Western New York. 1936.

RUBUS OCCIDENTALIS
Mosaic (rare). Cooley. Western New York. 1936.
Leaf curl (rare) Cooley. Western New York. 1936.

SORBUS PALLESCENS
Mosaic of apple. See *Pyrus.*

RUTACEAE

CITRUS sp.
Corrugations or ribbings of lemons. Casella. Italy. 1933. Not proved to be due to a virus.

SCROPHULARIACEAE

LINARIA VULGARIS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

PENTSTEMON sp.

Mosaic (cucumber virus 1). K. M. Smith. England. 1937.

VERONICA OFFICINALIS

Tobacco mosaic virus 1. Holmes. New Jersey. 1937.

SOLANACEAE

BROWALLIA SPECIOSA var. *major*

Tobacco mosaic virus 1. Holmes. New Jersey. I. 1937.

CAPSICUM sp.

Virus F (same as tuber blotch and Monocrat virus). Clinch, Loughnane & Murphy. Ireland. 1936. Also reported from Australia by Bald in 1937.

Bunchy top of tomato. McClean. South Africa. I. 1935.

CAPSICUM FRUTESCENS GROSSUM

Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

DATURA METELOIDES

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

DATURA STRAMONIUM

Virus F (same as tuber blotch and Monocrat virus). Clinch, Loughnane & Murphy. Ireland. 1936.

Streak (spotted wilt). Snyder & Thomas. California. 1936. This is a combination of streak with pea virus 1 and pea virus 3.

DATURA TATULA

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

LYCOPERSICUM ESCULENTUM

Tomato ring mosaic streak.

Tomato bushy stunt. *Lycopersicum* virus 4. Ainsworth. England. 1933.

Enation mosaic (fern leaf type). Ainsworth. England. 1935. Due to a virus related to common tomato mosaic virus.

Fern leaf, which may be different from the fern leaf in America. Ainsworth. England. 1935. It was reported as a new disease. The virus appears to have about the same host range as tobacco virus 1 and it is thought that it should be considered a strain.

A virus disease. Shapovalov & Dufrenoy. France. 1936. Also atacks *Callistephus sinensis*, *Dahlia* sp. *Nicotiana tobacum.* Transmitted by *Thrips tabaci.*

Spotted wilt of tomato. Brittlebank. 1919. This corrects the date of the former record.

Leaf curl. Pal & Tandon. India. 1937. See *N. tabacum.*

LYCOPERSICON PIMPINELLIFOLIUM

Bunchy top of tomato. McClean. South Africa. I. 1935.

NICOTIANA BIGLOVII

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937. See *Brassica.*

NICOTIANA CALYCIFLORA

A new mosaic of cabbage. Larson & Walker. Wisconsin. 1937. See *Brassica.*

NICOTIANA GLUTINOSA

Streak (spotted wilt). Snyder & Thomas. California. 1936. This is a combination of streak virus with pea virus 1 and pea virus 3.

Leaf curl. Pal & Tandon. India. 1937. See *N. tabacum.*

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937.

NICOTIANA LANGSDORFII

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937.

NICOTIANA LONGIFLORA

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937.

NICOTIANA MUALTIVALVIS

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937.

NICOTIANA QUADRIVALVIS

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937.

NICOTIANA REPANDA

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937.

NICOTIANA RUSTICA

Yellow dwarf of potato. Black. New York. I. 1937.

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937

Leaf curl. Pal & Tandon. India. 1937. See *N. tabacum.*

NICOTIANA SYLVESTRIS

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937.

NICOTIANA TABACUM

A virus disease. Shapovalov. France. 1936. Transmitted by *Thrips tabaci.*

Big bud. New South Wales. 1936.

Ring spot No. 2. Price. New Jersey. 1936.

Virus F (same as tuber blotch and Monocrat virus). Clinch, Loughnane & Murphy. Ireland. 1936.

Yellow dwarf. Hill. Australia. 1937.

Ruffle leaf. Lehman. North Carolina. N. 1937.

A new mosaic of cabbage. Larsen & Walker. Wisconsin. 1937.

Leaf curl (five types due to four distinct viruses A, B, C, D and mixtures of two or more known as X and transmissible to all Turkish varieties and to *N. rustica, N. glutinosa, Solanum nigrum, Lycopersicum esculentum* and *Petunia* sp.) Pal & Tandon. India. 1937.

Bergerac ringspot. Virus 14.

Tomato streak. Lycopersicum virus 1.

Hyoscyamus mosaic. Hy virus 1.

Datura virus 1. K. M. Smith. England. 1937.

Ruffle leaf. Lehman. North Carolina. 1937. Resembles "kroepoek" of South African and Java.

Yellow mottle. Putman. Canada 1937. A member of the latent or X virus group.

PETUNIA sp.

Virus F (same as tuber blotch and Monocrat virus). Clinch, Loughnane & Murphy. Ireland. 1936.

Leaf curl. Pal & Tandon. India. 1937. See *N. tabacum.*

PHYSALIS (two species)

Bunchy top of tomato. McClean. South Africa. I. 1935.

PHYSALIS PERUVIANA

Spotted wilt of tomato. K. M. Smith. England. 1936.

SCHIZANTHUS PINNATUS

Spotted wilt of tomato. Taubenhaus. Texas. 1936.

SCHIZANTHUS RETUSUS

Witches' broom caused by an attenuated strain of potato Y virus Salaman. England. 1937.

SOLANUM (7 species)

Bunchy top of tomato. McClean. South Africa. I. 1937.

SOLANUM CAROLINENSE

Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

SOLANUM DULCAMARA

Aucuba mosaic of potato. Clinch. Loughnane & Murphy. Ireland. 1936.

SOLANUM ELAEAGNIFOLIUM

Mosaic. Young. Altstatt & Harrison. Texas. 1937 (1938).

SOLANUM NIGRUM

Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

Virus F. Bald. Australia. 1937.

Leaf curl. Pal & Tandon. India. 1937. See *N. tabacum.*

SOLANUM NODIFLORUM

Virus F (same as tuber blotch and Monocrat virus). Clinch, Loughnane & Murphy. Ireland. 1936.

SOLANUM ROSTRATUM

Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

SOLANUM TRIFLORUM

Curly top of sugar beet. Carter. California. 1930.

SOLANUM TUBEROSUM

Virus F (same as tuber blotch and Monocrat virus). Clinch, Loughnane & Murply. Ireland. 1936. Also Bald. Australia. 1937.

Tuber blotch virus (Solanum virus 8).

Spring head (same as stekelkoffen in Holland, curly dwarf and bukett disease). Result of mixture of mild mosaic virus and stipplestreak (acropetal necrosis) virus. Botjes. Holland. 1937.

NOTE: Reddick (1936) reported that acropetal necrosis virus was the same as vein banding virus.

NOTE: Correction: Viruses Hy. II and Hy. IV may be regarded as strains of potato mosaic virus. Virus Hy. III is entirely different and does not attack potato. Hy. IV may be same as potato virus X. This correction of the second supplement is made in accordance with request from M. A. Watson.

THEACEAE

THEA sp.

Curly leaf or Phloem disease. Gadd. Ceylon 1936.

THYMELACEAE

DAPHNE sp.
Greening (?) New South Wales. 1935.
Mosais (?) New South Wales. 1935.

TROPAEOLACEAE

TROPAEOLIUM MINUS
Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

UMBELLIFEREAE

APIUM GRAVEOLENS
Mosaic. New South Wales. 1935.

DAUCUS CAROTA
Yellows. Conn. & New York.

VIOLACEAE

VIOLA CORNUTA
Mosaic (cucumber virus 1). K. M. Smith. England. 1937.

VIOLA ODORATA
Curly top of sugar beet. Taubenhaus & Altstatt. Texas. 1936.

VIOLA TRICOLOR
Cucumber mosaic virus 1. K. M. Smith. England. 1936.

SECOND SUPPLEMENT TO THE INDEX OF VECTORS OF VIRUS DISEASES OF PLANTS *

By MELVILLE T. COOK, *Plant Pathologist.*

ACERTOGALLIA SANGUINOLENTA

1937. Yellow dwarf of potato. Potato to potato. Black. New York.

ANURAPHIS PIDA

1934. Atanasoff reported that this vector transmitted a mosaic among apricot, cherry, peach and plum.

APHIS RUBICOLA

1936. Leaf curl. Rasberry to rasberry. Cooley. Western New York.

APHIS FABAE

1936. Yellows. Beet to beet. Roland. Belgium.

APHIS GOSSYPII

1937. Mosaic. *Commelina nudiflora* to *Ananas sativus.* Carter. Hawaii.

BREVICORYNE BRASSICA

1937. New mosaic of cauliflower. Among susceptible *Cruciferaceae.* Tompkins. California.

1937. New mosaic disease of cabbage. Among susceptible varieties. Larsen & Walter. Wisconsin.

CAPITOPHORUS FRAGAEFOLIA

1936. Yellow edge. Strawberry to strawberry. Massee. England.

CICADULIA MBILA

1937. New disease. *Zea mays* to *Zea mays.* Storey.

DELPHACODES STRIATELLA

Transmits dwarf disease virus of rice.

FRANKLINIELLA sp.

1926. Spotted wilt of tomato. Tomato to tomato. Australia.

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* Journal of the Department of Agriculture of the University of Puerto Rico. 19(3): 407–420. July, 1935.

Journal of the Department of Agriculture of the University of Puerto Rico. 20(3): 729–739. July, 1936.

LYGUS PRATENSIS

1935. A virus disease. *Brassica* to *Brassica*. Kaufman. Germany.

MACROSIPHUM ILLINOIA

1937. Vein mosaic. Transmitted among *Melilotus alba, Pisum sativum* (several varieties), *Trifolium pratense, T. repens, T. hybridum, T. incarnatum* and *Vicia faba*. Osborn. New Jersey.

1937. Pea virus 2. *Vicia faba* to *Lathyrus odoratus, Melilotus* Leguminoseae. Murphy & Pierce. Idaho.

MACROSIPHUM PISI

1937. Pea virus 2. *Vicia faba* to *Lathyrus odoratus, Melilotus alba, Phaseolus vulgaris* (many varieties), *Pisum sativum, Trifolium incarnatum* and *T. pratense*. Osborn. New Jersey.

MACROSIPHUM SOLANIFOLII

1937. Mosaic. *Commelina nudiflora* to *Ananas sativus*. Carter. Hawaii.

MACROPSIS TRIMACULATA

1936. Little peach. Between peach and plum. Manns. Delaware.

1936. Peach yellows. Between several species of Prunus. Manns. Delaware.

MELANOPSIS FEMUR, M. BIVITTATUS, M. PLUBEUS and M. AUGUSTIPENNIS

1928. Spindle tuber. Potato to potato. Goss. Nebraska.

MYZUS CIRCUMFLEXUS

1928. Tulip mosaic. Tulip to tulip. Brierley & McKay. Oregon. One case.

MYZUS PERSICAE

1936. Virus F (tuber blotch and Monocrat virus). Clinch. Loughnane & Murphy. Ireland.

1936. Yellows. Beet to beet. Roland. Belgium.

1936. Mosaic. Beet to beet. Roland. Belgium.

1936. Iris mosaic. Iris to Iris. Brierley & McWhorter. U. S. Pacific Coast.

1937. New virus disease of cauliflower. Among susceptible *Cruciferaee*. Tompkins. California.

1937. Mosaic. *Commelina nudiflora* to *Ananas sativus*. Carter. Hawaii.

1937. New virus disease of cabbage. Among many susceptible species and varieties. Larsen & Walter. Wisconsin.

NOTE: A correction. This species does not transmit virus Hy. IV or potato virus X as stated in the first supplement.

MYZUS SOLANI

NOTE: McKay (1929) of Oregon reports that recent work does not indicate that this insect is a vector of tulip mosaic as previously reported.

RHOPALOSIPHUM PSEUDOBRASSICAE

1937. New virus disease of cauliflower. Among susceptible *Crucifereae.* Tompkins. California.

1936. A virus disease. Between *Dahlia* sp. *Callistephus sinensis, Lycopersicon esculentum* and *N. tobacum.* Shapovalov & Dufrenoy. France.

TOXOPTERA AURANTII

1933. Transmits a corrugation or ribbing of lemons. Casella. Italy.

THE WITCHES' BROOM OF TABEBUIA PALLIDA IN PUERTO RICO

By MELVILLE T. COOK, *Plant Pathologist.*

A witches' broom of *Tabebuia pallida* has been known for many years and has been attributed to several causes such as fungi and insects but without definite proof in any case. This abnormality develops during periods of rapid growth as numerous short shoots in which the leaves are smaller than normal. A few apparently normal shoots with normal leaves are usually present among the abnormal twigs. The nodes of the abnormal shoots are thick and the internodes short. A few flowers and an occasional short seed pod may appear in the broom. All the shoots are green for several weeks or months. This is followed by the death of some of the shoots and eventually the entire broom. A few new shoots may develop in the old broom during periods of active growth for years. In some cases the majority of branches on a tree develop these very unsightly brooms.

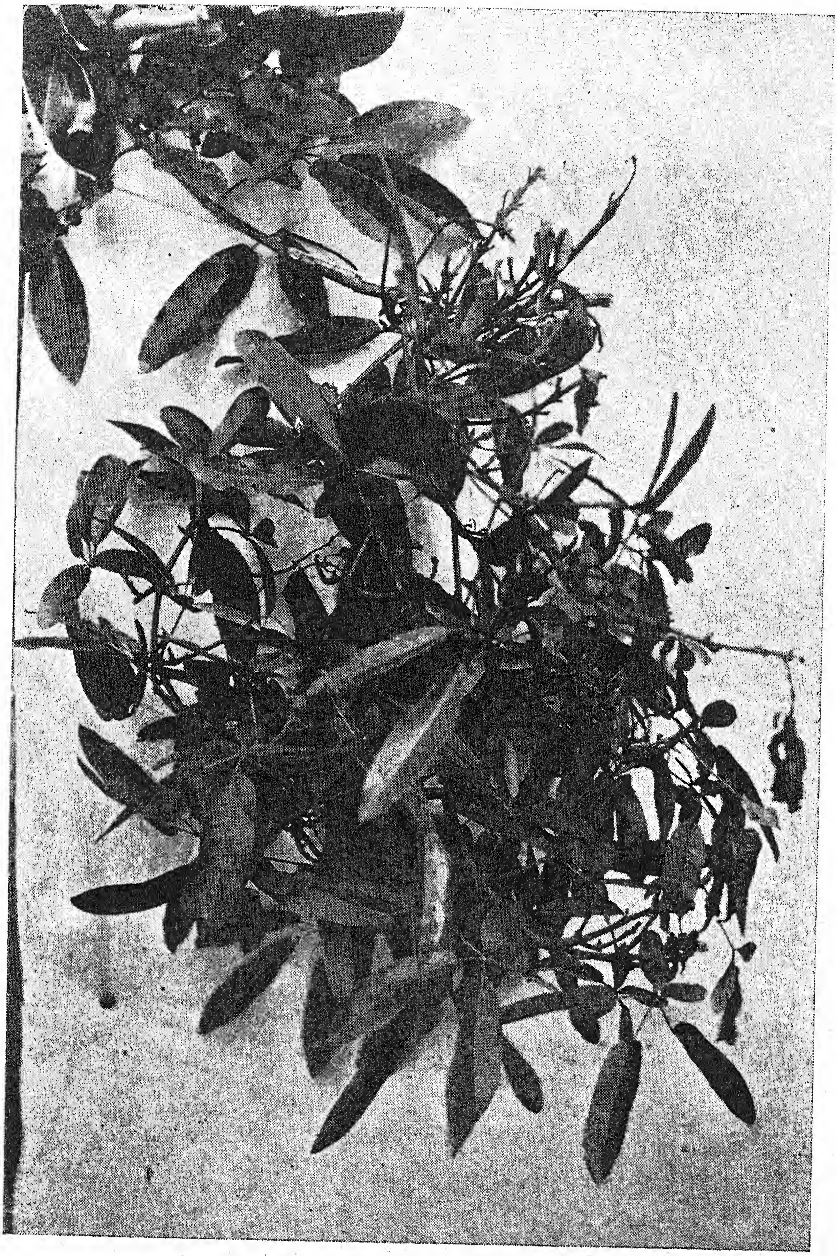
In the spring of 1936 the writer began a series of tests to determine the possibilities of this disease being due to a virus. Inoculations with the sap from diseased plants gave negative results. Budding with buds from diseased trees gave a low percentage of infections although the buds died. The studies indicate that the inoculations must be made during periods of active growths. The symptoms develop in three to four months after budding. The brooms usually appear at the nodes just above the points where the bud was inserted. After the formation of the first broom, other brooms will develop in other parts of the tree. These new brooms may develop on the branch in which bud was inserted or on other branches. The evidence indicates that the virus or active agent travels in both directions.

The illustration is the first broom developed by bud inoculation. The tree developed many brooms, some of them evidently from bud inoculations and others at other points.

Many seedlings have been grown but all of them aparently healthy. Therefore, it appears that the virus is not seed borne.

The source of infections in nature has not been determined but a leafhopper (*Protalebra tabebuiae* Dozier) lives in these trees and may be the vector.

Witches' brooms on many species of plants have been demonstrated as due to viruses. Some of the most important are potato (Hunger & Dana 1924 and Young 1926), strawberry (Zeller 1927), tomato (Young & Morris 1929) and *Holodiscus discolor* (Zeller 1930). Similar abnormalities such as rosette on several species of plants have also been demonstrated as due to virus diseases.



CUCUMBER MOSAIC IN PUERTO RICO

By MELVILLE T. COOK, *Plant Pathologist.*

During the winter of 1935–36 there was a severe outbreak of cucumber mosaic in Puerto Rico and in some fields all the plants were infected. The writer came to Puerto Rico in July 1923 and this is the first severe outbreak of the disease during the period beginning with that date. In fact, mosaic plants have been very rare. The symptoms of the 1935–36 outbreak were the same as those of the common mosaic in the eastern part of the United States. Diseased plants were rare in 1936–37. There was an abundance of *Aphis gossypii* Glover in the fields in 1935–36 but no experiments were conducted to determine if they were the vectors.

The source of this infection is an unsolved problem at this time. The seed came from the United States as in previous years, but it appears very unlikely that the disease came from that source, as the United States records show that it is rarely if ever transmitted by seeds of the cucumber but that it is transmitted by the seeds of the wild cucumber (*Micrampelis lobata*). Doolittle and Gilbert (1918) reported that one cucumber seed in 5500 produced a mosaic plant. The native wild cucurbits in the immediate vicinity of the fields in Puerto Rico did not show any symptoms of the disease but it is possible that they may be symptomless carriers. *M. lobata* does not occur in Puerto Rico. It is possible that the disease may be due to an entirely different virus from the common mosaic of cucumber in the United States. Bewley and Corbett (1930) reported a mosaic disease of cucumbers which appears to be entirely different from the mosaic cucumbers in the United States in that it was transmitted by the seeds.

The disease was so abundant that the writer decided to continue his studies on the effects of virus diseases on the histology of the host plants. In 1925, 1927, 1930 and again in 1931 the writer published papers showing the effects of viruses on the structure of the leaves and stated that some of the viruses caused an inhibition of the development of the chloroplasts. Several species of host plants were used in these studies. This idea was contradictory to the idea of destruction of the chloroplasts by viruses which had been held up to this time but has been supported by the studies of later workers.

A brief review of the more important work on this phase of the subject since that time is as follows:

Holmes (1931) published a paper on local lesions of tobacco mosaic which indicated changes or destruction at points of inoculation but he did not make histological studies.

Dufrénoy (1928) reported that in some cases chloroplasts did not reach the normal size while in other cases there was a disintegration.

Nelson (1932) said:

"In some cases, no disintegration of the chloroplasts is associated with the chlorosis but in others destruction of the chloroplasts is one of the contributing causes of the development and extension of the chlorotic areas."

* * * * * * *

"In the chlorotic areas, the chloroplasts may be fewer in number and smaller than those in the green portions, but, in some cases, there is no deficiency in number and the chloroplasts are normal in size. The affected cells are pale yellow in color and structural changes in the plastids are frequently to be observed. The stroma becomes flattened and larger in diameter and, as a result of dissolution processes, the chloroplasts eventually collapse into a coherent mass of viscous, pale yellow or colorless material with a more highly diffractive surface membrane at the surface."

Clinch (1932) said that her "observations on mosaic-infected leaves also show that inhibited developed is a feature of chlorosis in certain diseases, but the pathological effect, in potato at any rate, is considered to be more complex than Cook has suggested".

In the summary she said:

"The chloroplasts in the cells of the chlorotic areas also display inhibited development, as they are frequently smaller and fewer in number than in corresponding healthy cell. They may, however, be almost normal in size, but differ in other respects from the plastids of a healthy leaf."

Sheffield (1933) published a paper on the aucuba mosaic of tomato in which the results agreed with the writer. This may be summarized by the following extracts:

"As aucuba mosaic does not affect the chloroplasts of leaves which are fully developed at the time of infection, it seems unlikely that mature plastids are destroyed by the virus. The mottling of only young growing leaves suggests that the virus prevents the formation of plastids, and this has been found to be the case".

* * * * * * *

"If the virus reaches the cell before plastid development has commenced, then the development of the plastids is inhibited and usually they are destroyed."

* * * * * * *

"It should be emphasized that no evidence whatever was found of the destruction of mature plastids. Very occasionally the development of proplastids is inhibited during its course, but usually if a primordium is not destroyed or its development inhibited in a very early stage, then it will give rise to a perfectly normal chloroplast."

* * * * * * *

"The young cell responds in several ways to the virus attack. Cell growth is inhibited, simultaneously the proplastids are destroyed or their development prevented."

* * * * * * *

"In plants infected with aucuba mosaic certain of the leaf tissues are devoid of plastids and the cells may be undifferentiated. The absence of chlorophyll is brought about by the inhibition by the virus of the development of the plastid primordia. Usually the primordia are destroyed. If plastid development is not prevented in a very early stage, perfectly normal plastids are formed. Mature plastids are never affected by the virus but occasionally intermediate stages may be."

Esau (1933) reported disintegration of the chloroplasts in the leaves of curly top sugar beets.

Bawden (1934) published a paper on a foliar necrosis of potato in which he said:

"The plastids rapidly degenerate, their breakdown often being the first obvious sign of disease. Cells some distance from demonstrably necrotic ones frequently show plastids in all stages of degeneration."

A study of sections of mosaic and normal leaves and of the mosaic and normal parts of leaves of the cucumber in Puerto Rico showed that in most cases the mosaic leaves and mosaic parts of leaves were thinner than the normal leaves and normal parts of leaves.

The palisade cells were always longer in the normal than in the mosaic areas. In some cases the palisade in the mosaic had remained undeveloped and were cuboidal in shape (See figs. 1 to 6).

The chloroplasts were always more numerous and usually larger in the normal than in the mosaic (figs. 1–6).

All the above facts are in harmony with the previous work of the author and with the work of Clinch and Sheffield. It would be presuming entirely too much to say that all viruses have this effect on all species of host plants until the effects of more of them have been studied but it opens a field of research.

Studies were also made of the chlorotic and green areas of the fruits (Figs. 7 & 8). In general it may be said that there is very slight if any differences in the size of the palisade cells but number of chloroplasts in the chlorotic cells was much less than in the green areas.

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Explanation of Plates

1. Cross section of normal part leaf near tip.
2. Cross section of mosaic part leaf near tip.
3. Cross section of normal part leaf six inches back.
4. Cross section of mosaic part leaf six inches back.
5. Cross section of normal part.
6. Cross section of mosaic part leaf same section.
7. Section of epidermis of normal fruit.
8. Section of epidermis of mosaic fruit.

Note that the sections of normal leaves 1, 3 and 5 are thicker than the sections of the mosaic leaves 2, 4 and 6 and that the chloroplasts in the normal leaves are larger and more numerous than in the corresponding leaves of the mosaic plants.

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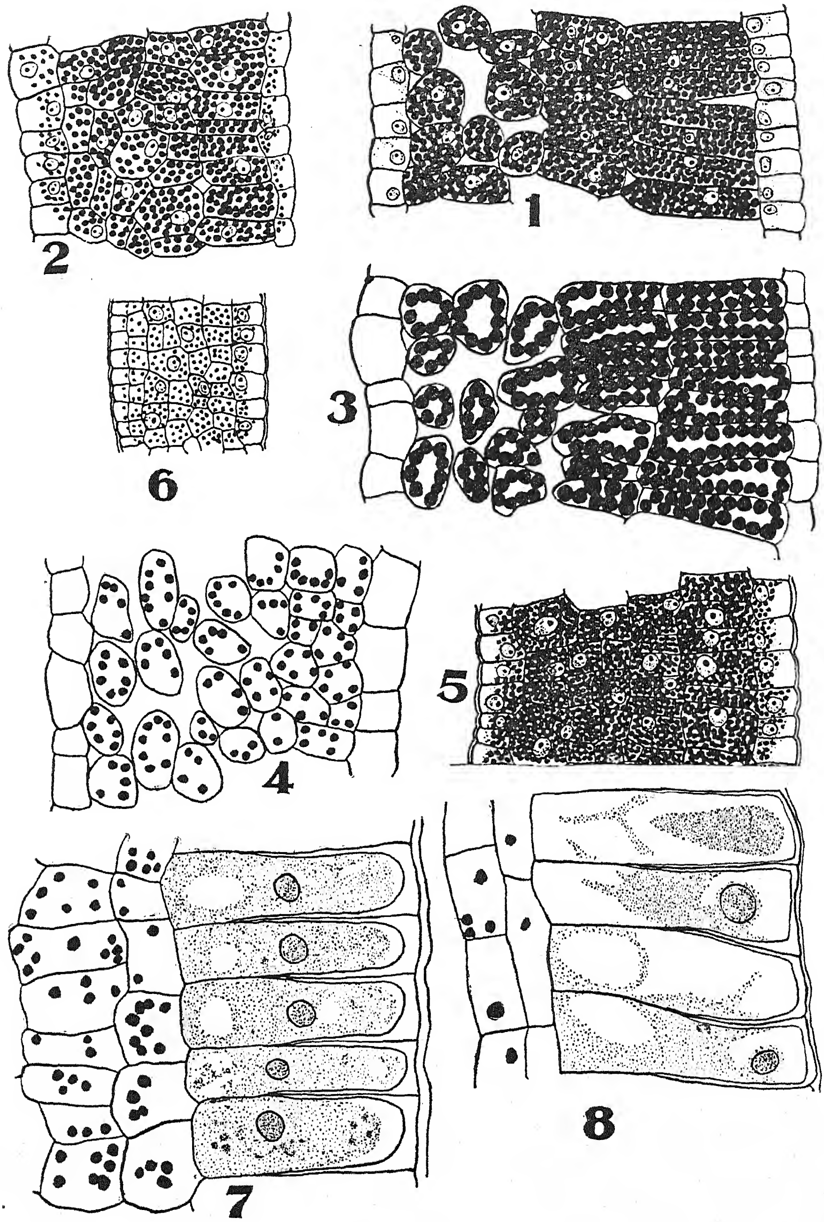
PLATE XII



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PUGILLUS FUNGORUM VENEZUELENSIS

RAEAEL A. TORO[1]

Since the publication of Chardon & Toro's Mycological Explorations of Venezuela (1), in which the number of known species of Venezuelan fungi was raised to a little over 1100, there have appeared a few short papers dealing with this subject. Sydow (4) adds seven new species in a revision and addition to his former Fungi Venezuelani; the author (5) adds three, and Kern (2), four, in their respective reports of the expedition of Kern and Toro in 1934. Linder (3) presents the results of his studies of several members of the Imperfecti collected by Chardon & Toro in 1932.

The present paper represents an attempt to identify some of the specimens which were collected in the course of the several trips to Venezuela.

IRENE LARVIFORMIS (P. Henn.) Stev., Annal. Myc. **25**: 425. 1927.

Meliola larviformis P. Henn. Hedwigia **43**: 362. 1904.

Appendiculella larviformis (P. Henn.) v. Höhn., Sitz. K. Akad. Wien. **128**: 556. 1919.

This is one of the few species of the group Meliolinae which show extreme pathogenesis in the host tissue. It forms brown necrotic lesions, surpassing the boundaries of the fungus colony. Another characteristic of this species is its susceptibility to epipathogens. None of the colonies examined were free from ether *Helminthosporium* or *Calonectoria* sp.

On *Acalypha macrostachya* Jacq.

La Cumbre, road to Ocumare, Aragua, Chardon & Toro No. *692*. July 25, 1932.

[1] Contribution No. 9, from the Department of Botany and Plant Pathology, College of Agriculture and Mechanic Arts, Mayagüez, P. R. Published with the authorization of the Dean.

IRENINA DALECHAMPIAE Stev., Annal. Myc. **25**: 449. 1927.

This species was hitherto only known from Ecuador. It may be also present in Colombia as this second collection comes form the Venezuelan llanos.

On *Dalechampia scandens* L.

Hacienda Santa Bárbara, El Palmar, Bolívar, H. Soltero, No. *1545*, Nov. 8, 1932.

MELIOLA PITHECOLOBII Stev. & Tehon., Myc. **18**: 9. 1926.

Our specimen agrees with the description of the species. Some of the setae merge in their length with that of *M. Meibomiae* Stev. & Tehon and a closer study may reveal that both are identical.

On *Pithecolobium* sp.

Upata, Bolívar, H. Soltero No. *1539*. Nov. 5, 1932.

MELIOLA SAPINDACEARUM Speg., Rev. Argentina Hist. Nat. **1**:29. 1891.

This species has been previously reported from Venezuela on other hosts.

On *Sapindus saponaria* L.

Heda. El Recreo, San Fernando de Apure. H. Soltero No. *1567*. Dec. 1, 1932.

Schiffnerula paraparensis sp. nov.

Fungus epiphyllous, forming loose, irregularly distributed, blackgray, superficial colonies, often covering the whole surface of the leaf; mycelium brown pellucid, septate, nearly straight, 6–7μ thick; hyphopodia alternate, one per cell, round, entire, about 10μ in diameter; sarciniform conidia, dark, four celled, globose; fusiform conidia bron, tranversely sepwtate: fruit bodies few, subglobose, same color as the mycelium, at firt parenchymatous and of elongate cells, later without cellular structure, sometimes breaking irregularly and exposing a clear hyaline substance, 60–80 u in diameter; asci ovoboid, 8–spored, few in number, 36–45μ in diameter, spores two celled, unequally septate, one cell round, the other conical slightly constricted, thick walled, light olivaceous, 20 × 10μ. (Plate I. Figs., 5–6–8).

Plagulae semper epiphyllae, tenues, irregulariter densiusculeque sparsae, superficialiae, atro-grissea, plus minus effusae et magnam folii partem occupantes; mycelium ex hyphis plerumque rectiusculis, remotiusculis septatis pellucide bruneis constans; hyphopodia alternantia, continua, leves globosa; conidia sarciniformes 4–cellularia, fuliginea; conida fusiformes brunneas, septata; perithecia pauca, subglobosa, mycelio concoloribus, contexto primum parenchymatico dein superne anhystus per aetatem irregulariter disrupta, stratum interius diaphanum hyalinum relinquentia; asci ovoboidis octoni, puaci; sporae uniseptatae, loculis plerumque parum inaequalis.

A folia viva *Bursera tomentosa* Tr., y Planch, Prope Parapara, ad vias, Chardon et Toro No. *712*. *(Typus)*. July 27, 1932.

The species is closely related to *Schiffnerula pulchra* (Sacc) Pet. with which it has many points of similarity, such as the shape and form of the young perithecia and the possession of two different types of conidia. It may be said it is a parallel species which has developed under different environmental conditions.

The systematic position of the genus *Schiffnerula* v. Hohn. has been amply discussed by Petrak (Ann. Myc **26**: 395. 1928). However, he based his conclusions not on examination of the type species; but on other material referred to that species. The same is true with respect to the genus *Questieria* Arnaud which he considers a synonym, differing from *Schiffnerula* v. Hohnel in the possesion of Sarcinella-like bulbils.

The author was fortunate to study both, the type of *Schiffnerula, S. mirabilis* v. Hohn and of *Questieria, Q pulchra* (Sacc.) Arn., and to compare these with the specimens examined by Petrak (Elmer No. *2007* from Borneo and Rabh. Fung. Europ. No *2149*). In the case of *S. mirabilis* v. Hohn, on *Passiflora foetida* (Schiffner No. *2723*, Urwald von Depock, Buitenzorg, Java), type of the genus, the general characters are as described by Petrak for the Borneo material. However, there is also present some conidia resembling a brown *Fusarium*, which are probably the structures refered to by V. Hohnel (Fragm. z. Myk. *330*. 1909) when he mentions "sitzenden quergeteilten condien". These are also figured in the original package. No such conidia are mentioned by Petrak, but they are described and figured by Arnaud (Les Asterinees *I*. pag. 188 et. pl. XLI. fig. B. 1918) for *Questieria pulchra* (Sacc) Arn. as "spores resemblant a celles des Fusarium. . .". In addition to this type of conidia there is in Arnaud's (Desm. Pl. Crypt. de France No. *404*)and our, material (but not in v. Hohnel's) a second form. This is of the *Sarcinella*-type, four celled, dark brown bulbils sorrounded by a hyaline, gelatinous-like substance. Thus, this Sarcinella-form represents the only difference between *Questieria* Arn. and *Schiffernula* v. Hohnel. But such form is not always constant, as *Questieria monotheca* (Pat. & Gaill) Arn., the first species described under the genus, do not possess said conidia.

In view of these facts we are inclined to agree with Petrak and consider *Questieria* a synonym of *Schiffernula*. The presence of the bulbis of the Sarcinella-type in *S. pulchra,* in our material, and in several other akin forms, can be best explained, using Arnaud's (l. c. pg. 189) own words, as "un moyen de résister aux conditions défavorables d'un climat différent de celui on l'on recontre habituellement".

ANTIMANOA GRISLEAE Syd., Annal. Myc. **28** : 170. 1930.

Myocopron Guiscafrei Toro Monog. Univ. Porto Rico. **2** : 94. 1934.

An examination of the type of *Antimonoa* at the Farlow Herbarium, Harvard University, show that our previous determination belongs to this genus and that the host is also the same. Therefore, both are corrected here.

On *Grislea secunda* Loefl. Chardón and Guiscafré No. *560*, Knoop's Park. Los Teques.

ASTERINA ECHIONOSPORA v. Hohn. Sitz. del K. Akad. Wisc. in Wien. **119** : 440. 1910.

Our specimen agrees in general characters with the type from Ceylon (Thwaites No. *497*) on *Canejera Rheedii*. The echinulation of the unequally septate spores is typical. This is the first report of the species in America. (Plate I, Figs. 4 – 7.)

On *Ximenia americana L.*

Road Beyond Petare, Chardón and Toro No. *461*, July 8, 1932.

Kerniomyces gen. nov.

Mycelium superficiale nullum; stromata sparsa, omnino superficialia, dimidiato-scutata,, membrana basali distincta nulla, strato tegente convexulo reticulato-plectenchymatico plus minus intense olivaceo-brunneo, plica tennui lineariformi simplici rima longidutinali aperta praedita; asci numerosi, clavati, octoni; stratis plus minus crassis contextis separati; sporae elongato fusoideae, septa transversalis divisae, hyalinae.

Est Myriangella Zimm. thyriothecia linearia longitudinalis dehiscentibus.

A mycologo præclaro F. D. Kern, in Collegi Pennsylvaniensis Professori. de estudio Flora Tropicalis impirmis merito.

This interesting fungus gives, at first sight, the impression of a *Lembosia* devoid of superficial mycelium. The character of the fruit body and the absence of mycelium places the fungus in the Hemisphæriacea. Shear and Clements (Gen. Fung. pg. 99. **1931**) include in this Family *Hadotia* Maire which possess long fusoid, multiseptate spores and longitudinally dehiscing fruit bodies. An examination of Maire's drawings and discussi on (Bull. Soc. Sc. Nancy III: **16**: 177, Fig. 2, 1906) shows clearly that his, is an Hysteriaceous form, related to the type of *Lophodermium* occuring on grasses. Moreover, his illustration shows that the fungus is subcuticular and not superficial, as mentioned in the text. Another genus with spindle shaped

spores but sub-cuticular perithecia is *Moesziella* Pet. In this genus, the fruit bodies are borne in a collective stroma and dehiscence is not always longitudinal. Also *Phychopellis* Syd. is a *Mycrothyrium* Desm. opening by long slits. *Stigmatophragmia* Tehon & Stout has also a subcuticular ascoma; *Schizothyrium* Desm has two celled spores while *Phragmothyriella* v. Hoehn., as pointed out by the author (Mycol. **19** : 71. 1927) is a synonym of *Myriangella* Zimm, and possess a round thyriothecium.

Type species the following:

Kerniomyces costi sp. nov.

Colonies amphigenous, widely separate, 2.5–5 mm. in diameter grayish black, not shiny, smooth; evident superficial mycelium absent; thyriothecia lineal, longitudinally dehiscent, lembosioid, rarely y-shaped by confluency, margin entire, composed of olivaceous brown, septate cells which form a close network, apperture 40–80 u wide; exposing the contents which are hyaline when fresh, brownish when dry, 123–138 × 176–274μ; asci numerous, ellipsoid, tunicate above, short pedicellate, 8-spored, somewhat bent, separated by a thick-gelatinous, paraphysoid tissue which is hyaline-olivaceous at first brownish with age, 58–68 × 18–26; spores filiform, distributed in two rows or somewhat inordinate, thin walled, 3–4 septate, not constricted, hyaline, 29–37 × 4–6μ. (PLATE I, FIGS. 1–2–3.)

Plagulae amphigenae irregulariter laxeque disperseae, atrogriseae, tenues; mycelium superficiale nullum; thryothecia densiniuscule distributa, semper exacte lembosioidea, linearia, recta vel curvata, haud raro in forman signi Y confluentia, rima angusta longitudinali aperta; asci ellipsoidei, antice late rotundati, postice brevissima stipitati, octoni, sporae distichae vel fasciculatae, clavulatae, hyaline, ad septa non constrictae.

Ad folia viva *Costus macrostachys* H. B. K., Toro No. *93*, prope Ocumare de la Costa ad vias, Dec. 1930.

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Explanation of Plate

Kerniomyces Costi gen. et. sp. nov.

Fig. 1. Photomicograph of the thyriothecium.

Fig. 2. The gelatinuos matrix in fruit body. Note the ascus with multiseptate spores imbedded in it.

Fig. 3. Photograph of a piece of the leaf of *Costus macrostachys* showing a number of the fruiting bodies.

Asterina echinospora v. Hohn.

Fig. 4. Leaf of *Ximensia americana* showing distribution of fungus.

Fig. 7. Fruit body of *Asterina echinospora.*

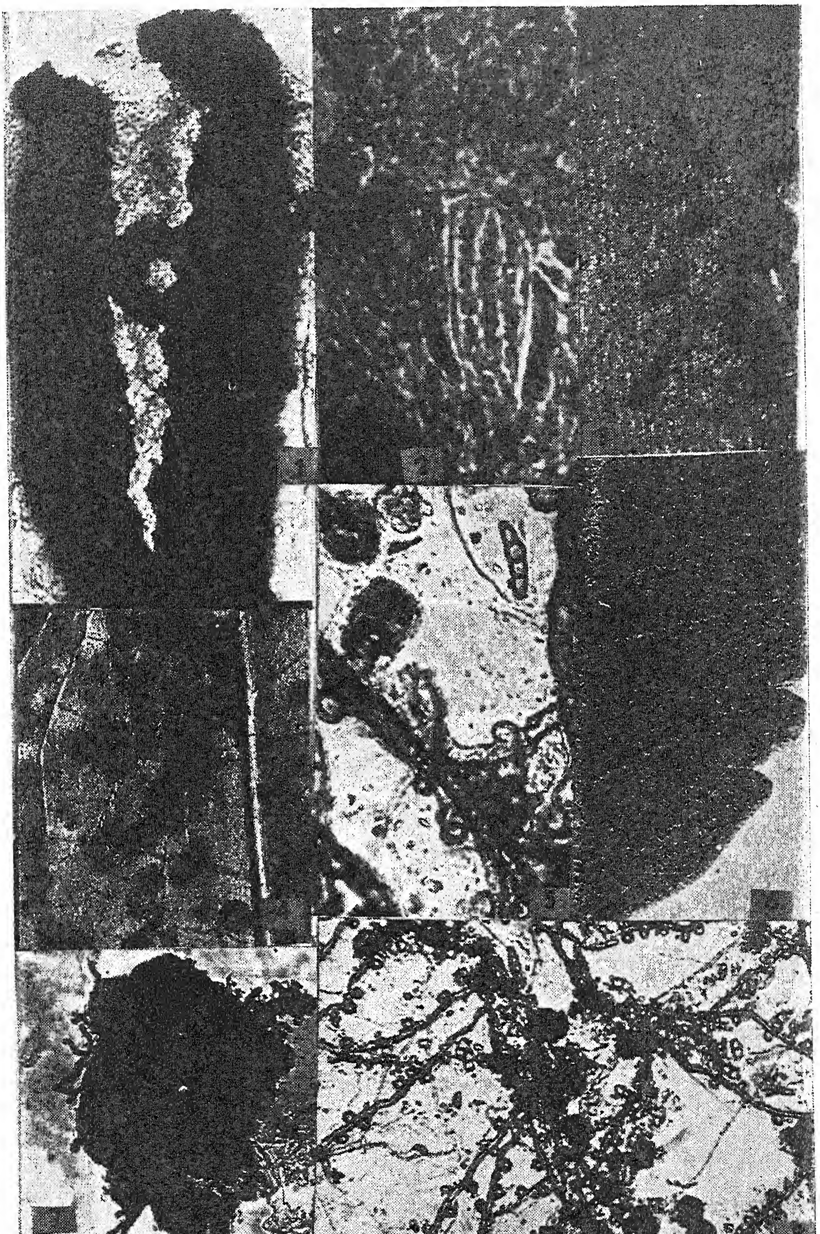
Shiffnerula paraparencis sp. nov.

Fig. 5. High power micophotograph of mycelium and bulbills. Note the Fusarium-like brown spore.

Fig. 6. Leaf of *Bursera tomentosa* showing the moldy appearance of fungus.

Fig. 8. Low power micophotograph of mycelium, hyphopodia, bulbilis and conidia.

PLATE XIII



THE NUTRITIVE VALUES OF SOME FORAGE CROPS OF PUERTO RICO [1, 2, 3]

II. Legumes, Grasses and a Mixture

By JOSEPH H. AXTMAYER, G. RIVERA HERNÁNDEZ and D. H. COOK, of the Department of Chemistry, School of Tropical Medicine, San Juan, Puerto Rico.

The studies reported in this paper and that published previously (1) are reports of investigations which aim to gather information concerning the nutritive values of forage crops used in Puerto Rico, or which could be used, after a complete study of their nutritive values. This would be especially valuable in the case of new crops used in soil conservation, and we believe that studies of this type will help materially in encouraging the planting of good forage crops, thus reducing the cost of production of milk and other animal by-products. Puerto Rico imports large quantities of concentrates for use in the dairy industry.

It seems to be unnecessary to review the literature relating to the methods used in conducting such a study, since this has been done repeatedly in the States. The papers consulted have already been reported in the previous article (1) and are given (2) at the end of this paper.

MATERIALS AND EXPERIMENTAL DETAILS

The animals used in our digestion trials were native sheep, of ages ranging from six to eight months when purchased.

The grasses and legumes studied, viz., Yaraguá and Merker grasses, soy bean in bloom and full pod, velvet bean in bloom and full pod, and pigeon pea before the blooming stage, were grown at the Station at Río Piedras. The material was cut early every morning and brought to us. It was then cut up into pieces ranging from two to four inches in length before weighing and feeding.

Metabolism cages 3½ feet long, 2 feet wide and 3 feet high, were used for the sheep. Each cage was provided with a screen top for ventilation and a double bottom for the collection of the feces and urine separately. The box containing the feed and water can was

[1] Cooperative project between the Agricultural Experiment Station of the University of Puerto Rico and the School of Tropical Medicine.

[2] Field work was conducted at the Experiment Station at Río Piedras.

[3] Study made possible from grant-in-aid of the Bankhead-Jones Act of the U. S. Congress, 1936.

placed in the cage in such a manner as to reduce scattering to a minimum.

The animals were kept in a cemented floor stable during a ten-day preliminary period on the ration which was to be tested. They were then transferred to the cages and the experimental period proper, of another ten days duration, was begun.

The following data were collected during each of these ten-day experimental periods: (1) initial and final weights of the experimental animals; (2) daily weights of the feed offered; (3) daily weights of the feed refused; (4) daily weights of the feces eliminated; (5) daily volumes of water offered and refused; and (6) daily volumes of urine eliminated. These data were collected at the same hour every day, and aliquots of the feed offered and refused and of the feces and urine eliminated were taken to the laboratory for analysis.

All analyses reported in this study were performed in accordance with the Methods of the Association of Official Agricultural Chemists.

The solid samples were dried in an air oven at 100°C. The composite aliquot samples of the feces and the urine were kept in a refrigerator, xylol being added to the urine as a preservative. The samples of dried feed and refuse were kept in closed paper bags and ground in a Willy mill at the end of each experimental period. The feces were treated in the same manner. The ground material in each case was thoroughly mixed and sufficiently large portions were put into bottles provided with screw stoppers to be preserved for analysis. The indicator used in the titration of the acid solution in which the ammonia was collected, upon the distillation of the diluted solution obtained during the Kjeldahl digestion, was a solution made up of ten parts of a saturated methyl red solution in 50 per cent of alcohol and one part of a 0.25 per cent solution of methylene blue in water. This indicator gives a very sharp end-point.

The results obtained in last year's experiment for the determination of the endogenous and metabolic nitrogen when sheep were fed a nearly nitrogen free ration were used in this study.

Data and Discussion

A total of fourteen digestion trials, together with all the chemical analyses required, was performed during the year. Table A, which records the schedule followed in these trials, contains also informa-

tion regarding the stage of maturity of the material, the fertilizer applied and the number of animals used in each trial. We used a mixture composed of $1\frac{1}{4}$ parts by weight of Merker grass and 1 part of pigeon pea in Trial 14 as preliminary to the type of trials which are being planned for next year. The number of animals used in each trial was larger than that used last year. This was done for the purpose of eliminating individual differences as much as possible.

Table I contains a summary of the weights of the wet and dry feed and feces consumed and eliminated, respectively, and of the volumes of water consumed and urine eliminated in each of the fourteen trials. Since the animals would feed ad libitum, the amounts of feed and water offered was always greater than could be consumed.

The percentages of nitrogen in the feed, refuse and feces were calculated on the dry basis, while in the case of the urine, the analyses are given on the percentage by volume basis. These data are given in Table II. The highest content of nitrogen in the legumes studied was found in the pigeon pea, Trials 10 and 11. It will be noticed that the nitrogen in the refuse was found to be either higher, Trial 10, or equal, Trial 11, to the nitrogen of the feed. This is explained by the facts that the sheep consumed the leaves and stems in the same proportion as these were present on the fresh feed. Such was not the case with the other legumes. In the case of the grasses, the nitrogen in both the feed and refuse was higher for the Merker grass than for the Yaraguá grass.

Table III presents the values for the endogenous or urinary nitrogen, and the metabolic or fecal endogenous nitrogen excreted by sheep fed a low nitrogen but otherwise complete ration. These calculations have been taken from previous studies in this laboratory and are applied in the calculations of the biological values of the proteins of the various legumes and grasses studied.

A summary of the data collected during the trials upon which the determinations of the biological values of the proteins are based is given in Table IV. The protein efficiency or biological value of a feed is taken as the total nitrogen retained by the experimental animal in percentage of the total nitrogen absorbed. It is also denoted as the percentage of the total intake absorbed. Differences in the digestibilities of different proteins do not affect their biological values although these may vary with the use the body makes of the protein. Sufficient non-nitrogenous food must be taken into the

body when the biological value of a protein is determined so that none of the protein will be utilized as a source of energy. There must be an intake of protein large enough to indicate a positive balance, but not too high to be in excess of the quantity needed for maximum growth because this excess intake will be effective in lowering its true biological value.

The mathemathical formula used in calculating the value is given as follows:

$$\text{Biological value} = 100 \times \frac{\left[(\text{Food N} - \text{Food N in feces} - \text{Body N in feces}) - (\text{Urine N} - \text{Body N in urine})\right]}{\text{Food N} - (\text{N in feces} - \text{Body N in feces})}$$

$$\text{or} \qquad 100 \times \frac{\text{Food N retained}}{\text{Absorbed N}}$$

The terms "Body N in feces" and "Body N in urine" refer to the metabolic nitrogen in the feces and the endogenous nitrogen in the urine, respectively, as determined in a digestion trial with the animals receiving a nitrogen-free or nitrogen-low ration. The former term is obtained by multiplying the weight of the total dry feed intake by the metabolic nitrogen in the feces per gram of dry nitrogen-free matter ingested, while the latter term is calculated by multiplying average body weight of the animal in kilograms by the endogenous nitrogen per kilogram of body weight.

It will be noticed that the results show low biological values for the legumes studied, although they seem to be in accordance with the data on legumes obtained in the United States. Since legumes are rich sources of proteins, a high intake is to be assumed in an ad libitum feeding trial, and this will tend to give a low biological value.

The value for the Merker grass is the lowest obtained for any of the grasses studied so far. We are planning to repeat these trials, since this grass is believed to be of good forage value.

Tables V and VI contain the data relating to the proximate chemical compositions of the forage crops studied. The methods of the Association of Official Agricultural Chemists were used in these analyses. Although the material was analyzed for total moisture as soon as received, it is possible that some moisture was lost during packing and transportation.

The proximate analyses on the dry basis of the feed fed and refused and of the feces eliminated are given in Tables VII and VIII, respectively.

The individual coefficients of apparent digestibilities of the nutrients in the legumes and grasses, as determined with each animal in a trial together with the average value for each trial, are given in Table IX. There are also included the average biological values for each triai which has already been given in Table IV. The percentage of each nutrient in a feeding stuff which is digested is termed the coefficient of digestigility, or digestion coefficient, for that nutrient in the feed. The values are computed with the following equation:

$$\text{Coefficient of apparent digestibility} =$$

$$100 \times \frac{\text{Substance in the feed fed} - \text{Substance in the feces eliminated}}{\text{Substance in the feed fed.}}$$

The digestibilities of nutrients in a concentrate cannot be determined by conducting digestion trials in which the concentrate constitutes the whole ration, because of insufficient bulk. Coefficients of digestion of the ash are not given, because at present no method is available by means of which correct values for the digestibility of mineral elements may be obtained. It has been shown that part of the absorbed minerals are excreted through the gut and cannot be separated from that part of the feed which is not absorbed. Digestion coefficients are used in calculating the amount of digestible nutrients in a feed, thereby measuring its nutritive value.

The values for the digestible nutrients per hundred weight as determined with the data given above for the legumes and grasses studied are given in Table X. There are also included in this table values for the nutritive ratios. This term applies to the proportion, or ratio, between the digestible crude protein and the combined digestible carbohydrates and fat. In computing the ratio, the total digestible fat is multiplied by 2.25 because fat produces this times as much heat in being oxidized in the body as do the carbohydrates.

The formula used in computing the second term of the ratio is:

$$\frac{(\text{Digestible fat} \times 2.25) + (\text{Digestible carbohydrates})}{\text{Digestible crude protein}}$$

The second term of the numerator includes the digestible crude fiber. The term nutritive ratio is used to denote the proportion of digestible protein in comparison with the other nutrients.

Nutritive ratios may be narrow, that is, when the feed has much digestible crude protein in proportion to the digestible carbohydrates and fat; and wide, when the reverse is true. The digestibility of

all nutrients in a feed tend to be lowered as the nutritive ratio widens. This is especially true for proteins, being less specific for the other nutrients.

Table XI contains data relative to the yield per cuerda * of digestible nutrients of the green legumes studied.

By the use of the average percentages of total protein in feeds, the average coefficients of digestion, and the average biological values it is possible to compute the "net protein" values of feeds as shown by Mitchell and Villegas (8). The value is obtained by multiplying the value for the coefficient of digestibility, which gives us the content of digestible protein in the feed, by the biologival value and dividing by 100. This value may be of use in evaluating a feed or diet with respect to its ability to satisfy a given protein requirement or in the preparation of a ration which would meet the protein requirement of an animal most satisfactorily under specified conditions. The data for the "net protein" values for the legumes studied are given in Table XII.

Table XIII has been prepared to show the total yield in calcium and phosphorus per cuerda and per ton of the legumes studied.

The fattening capacity of the legumes and Merker grass are given in Table XIV while Table XV contains a summary of the nutritive indexes determined in these studies.

Summary

The biological values of the proteins of the legumes studied range from 32 to 63. These are lower than the value for the Yaraguá grass or for the grasses studied previously. The low values obtained for the legumes are explained on the basis of a higher intake of protein when the legumes are fed alone, since it has been repeatedly shown that biological values decrease with an increase in the protein level intake. Soy bean in the full pod stage yields the highest biological value of the legumes studied.

Pigeon peas, before blooming, show, on the dry basis, the highest percentage of crude protein and the lowest for ash of the legumes, while the ether-soluble extract percentage is second highest to soy bean in the full pod stage.

The sheep fed the Yaraguá grass left the greatest amount of refuse. This grass has a characteristic odor and taste which seems to make it unpalatable.

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* A *cuerda* is a unit of land measure used in Puerto Rico equivalent to 0.954 of an acre.

The coefficients of digestibility for the different nutrients are lower for Yaraguá grass than for the legumes studied.

Soy beans in the full pod stage of maturity yield the highest value for the total digestible nutrients followed closely by the pigeon pea in the before-flowering stage.

The nutritive ratios obtained are narrow with the exception of the Yaraguá grass which have a very wide ratio.

The yield of total ether-soluble extract in pounds per cuerda is highest in the case of the soy bean in the full pod stage of maturity. The velvet bean in the same stage yielded the highest weight of total crude protein and of total digestible matter.

The "net protein" values as obtained with the legumes is highest in the case of the soy bean in the full pod stage, being followed by the velvet bean in the same stage of maturity.

Pigeon peas in the before-flowering stage of maturity show the highest fattening value of all the legumes studied. The Merker grass value is far below that of any of the values for the legumes.

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THE NUTRITIVE VALUES OF SOME FORAGE CROPS OF PUERTO RICO

I. Grasses.

Corrections:

On page 106, the third line of the heading of Table 2 should read: "and Body Nitrogen in Urine per 1000 Grams of Body Weight, Based".

On page 107, under the column headed by "Body Nitrogen in Urine Per Kilogram of Body Weight" should read 0.535 instead of 0.801 and 0.372 instead of 0.335. Under the column headed by "Average Body Nitrogen in Urine Per Kilogram of Body Weight" should read 0.561 instead of 0.526.

TABLE A

SCHEDULE FOLLOWED STARTING SEPTEMBER 22, 1937 TO MARCH 29, 1938

Trial No.	Ration	Preliminary Period		Experimental Period		Animal Number
		Starts	Ends	Starts	Ends	
3........	Soy Bean (in flower) N-P-K Otootan variety..........	Oct. 12..	Oct. 22..	Oct. 22..	Nov. 1..	16-17-18-20-21
4........	Soy Bean (in flower) N-P-K Otootan variety..........	Oct. 22..	Nov. 1..	Nov. 1..	Nov. 11.	40-41-42-43-44
5........	Soy Bean (in full-pods) N-P-K Otootan variety..........	Nov. 1..	Nov. 11.	Nov. 11.	Nov. 21.	16-17-18-20-21
6........	Soy Bean (in full-pods) N-P-K Otootan variety..........	Nov. 11.	Nov. 21.	Nov. 21.	Dec. 1..	40-41-42-43-44
7........	Velvet Bean (in flower) N-P-K.....................	Nov. 21.	Dec. 1...	Dec. 1...	Dec. 11..	16-18-20-21
8........	Velvet Bean (in flower) N-P-K.....................	Dec. 1..	Dec. 11.	Dec. 11.	Dec. 21.	40-41-42-44
9........	Velvet Bean (in full-pods) N-P-K.................	Jan. 2...	Jan. 12..	Jan. 12..	Jan. 22..	16-17-18-19-20-21
10........	Pigeon Pea (before blooming) N-P-K.................	Jan. 22..	Feb. 1..	Feb. 1 ..	Feb. 11.	16-17-18-19-20-21* 1- 2- 3- 4-40-44
11........	Pigeon Pea (before blooming) N-P-K.................	Feb. 1..	Feb. 11.	Feb. 11.	Feb. 21.	16-17-18-19-20-21
1........	Yaragua, N and P.........	Sept. 22.	Oct. 2...	Oct. 2...	Oct. 12..	16-17-18-20-21**
2........	Yaragua, N and P.........	Oct. 2...	Oct. 12..	Oct. 12..	Oct. 22..	40-41-42-43-44
12........	Merker Grass (N only)....	Feb. 11.	Feb. 21.	Feb. 21.	Mar. 3..	1-3-4-40-41
13........	Merker Grass (N only)....	Feb. 21.	Mar. 3..	Mar. 4..	Mar. 14.	16-17-18-19-20-21
14........	Merker Grass (N only) 1¼+ Pigeon Pea (before blooming) 1.............	Mar. 9..	Mar. 18.	Mar. 19.	Mar. 29.	1-3-4-5-6-41

*All animals in preliminary period.
**This trial is not included in the calculations.

TABLE I

SUMMARY OF THE WET AND DRY FEED AND FECES CONSUMED AND ELIMINATED RESPECTIVELY, AND OF THE WATER INTAKE AND URINE ELIMINATION IN TEN-DAY METABOLISM EXPERIMENTS

Trial No.	Animal No.	Ration	Wet feed consumed Gm.	Feed on dry basis fed Gm.	Feed on dry basis refused Gm.	Feed on dry basis consumed Gm.	Wet feces Gm.	Dry feces Gm.	Water cc.	Urine cc.
3.......	16.......	Soy bean (in flower) Ototan variety NPK..	35250	7662	2332	5330	5307	2108	10015	24755
	17.......	Soy bean (in flower) Ototan variety NPK..	39148	7960	1983	5977	5769	2366	620	19165
	18.......	Soy bean (in flower) Ototan variety NPK..	33904	7439	2311	5128	4800	2044	460	14860
	20.......	Soy bean (in flower) Ototan variety NPK..	39010	8108	2222	5886	8557	2410	875	15405
	21.......	Soy bean (in flower) Ototan variety NPK..	32529	7439	2833	4606	4269	1910	630	16415
4.......	40.......	Soy bean (in flower) Ototan variety NPK..	45250	8736	2020	6717	10791	2766	430	18235
	41.......	Soy bean (in flower) Ototan variety NPK..	48553	9488	2282	7206	9567	3101	1795	23880
	42.......	Soy bean (in flower) Ototan variety NPK..	40665	8736	3023	5713	6364	2389	505	20435
	43.......	Soy bean (in flower) Ototan variety NPK..	45272	8736	2218	6518	7443	2569	730	21155
	44.......	Soy bean (in flower) Ototan variety NPK..	44743	8736	2139	6597	8819	2672	540	18950
5.......	16.......	Soy bean (full pods) Ototan variety NPK..	30729	10789	4178	6611	7525	2380	15010	20615
	17.......	Soy bean (full pods) Ototan variety NPK..	35616	12059	4101	7958	7161	2893	2480	13875
	18.......	Soy bean (full pods) Ototan variety NPK..	24960	10789	4982	5807	3421	1727	2880	9280
	20.......	Soy bean (full pods) Ototan variety NPK..	27959	10789	4557	6232	8406	2093	2865	5720
	21.......	Soy bean (full pods) Ototan variety NPK..	25411	10789	5224	5565	4204	1811	2210	9265
6.......	40.......	Soy bean (full pods) Ototan variety NPK..	29746	13624	6680	6944	8618	2380	6035	8795
	41.......	Soy bean (full pods) Ototan variety NPK..	32000	13624	5754	7870	10312	2957	9220	11910
	42.......	Soy bean (full pods) Ototan variety NPK..	32254	13624	6125	7499	10482	2694	5330	9180
	43.......	Soy bean (full pods) Ototan variety NPK..	34150	13624	5941	7683	8449	3242	4830	10540
	44.......	Soy bean (full pods) Ototan variety NPK..	31405	13624	6190	7434	10431	2833	4240	7155
7.......	16.......	Velvet bean (in flower) NPK...............	36859	10071	3445	6626	7499	2137	7440	18805
	18.......	Velvet bean (in flower) NPK...............	34685	10071	3531	6540	4050	1976	1060	17040
	20.......	Velvet bean (in flower) NPK...............	35146	10071	3697	6374	7104	1966	1750	12975
	21.......	Velvet bean (in flower) NPK...............	31699	10071	4318	5753	3426	1769	1200	16055
8.......	40.......	Velvet bean (in flower) NPK...............	30447	10467	4725	5742	6625	1809	1160	8820
	41.......	Velvet bean (in flower) NPK...............	38037	10467	3699	6768	10599	2728	3255	14190
	42.......	Velvet bean (in flower) NPK...............	39940	10467	3167	7300	9304	2572	2975	15365
	44.......	Velvet bean (in flower) NPK...............	36736	10467	3856	6611	9325	2245	2360	12145
9.......	16.......	Velvet bean (full pods) NPK...............	34766	11393	4759	6634	5060	1636	5220	19345
	17.......	Velvet bean (full pods) NPK...............	41187	12912	4648	8264	9832	2542	1920	15300
	18.......	Velvet bean (full pods) NPK...............	31045	11393	5260	6133	5169	1702	3240	16090
	19.......	Velvet bean (full pods) NPK...............	33676	11393	4824	6569	5157	1797	2340	17665
	20.......	Velvet bean (full pods) NPK...............	37671	11962	4479	7483	8522	1924	4640	14630
	21.......	Velvet bean (full pods) NPK...............	32098	11393	5230	6163	3883	1230	1140	15420

10	1	Pigeon pea (before blooming) NPK	20008	11050	6881	4169	5077	1984	315	5170
	3	Pigeon pea (before blooming) NPK	19830	11050	6462	4588	6519	2230	840	3470
	4	Pigeon pea (before blooming) NPK	21937	11050	6416	4634	6869	2291	1750	5130
	40	Pigeon pea (before blooming) NPK	19370	11050	6869	4181	7406	1808	2880	2950
	41	Pigeon pea (before blooming) NPK	29569	12155	5490	6665	9754	3252	5230	10545
11	16	Pigeon pea (before blooming) NPK	27832	14038	7804	6234	9339	2640	6720	6960
	17	Pigeon pea (before blooming) NPK	28917	14038	7152	6886	9125	2946	4175	6170
	18	Pigeon pea (before blooming) NPK	25087	14038	8035	6003	8855	2497	4465	4475
	19	Pigeon pea (before blooming) NPK	23280	14038	8283	5755	7310	2289	4385	6270
	20	Pigeon pea (before blooming) NPK	22372	14038	8724	5314	9374	2045	4605	3205
	21	Pigeon pea (before blooming) NPK	25519	14038	7948	6090	6964	2444	4620	7530
2	40	Yaragua (N and P)	26860	10088	4043	6045	8766	2959	700	6965
	41	Yaragua (N and P)	19667	9507	5024	4483	4337	2269	8125	15465
	42	Yaragua (N and P)	21685	9507	4534	4973	5024	2426	3050	10055
	43	Yaragua (N and P)	26945	10318	4602	5716	9067	3093	3400	8530
	44	Yaragua (N and P)	22457	9623	4552	5071	5067	2463	2485	8940
12	1	Merker grass (N only)	24543	11153	6005	5148	4726	2133	330	8270
	3	Merker grass (N only)	27010	11897	5699	6198	8031	2402	110	6830
	4	Merker grass (N only)	28276	11897	5826	6071	5433	2592	1510	11480
	40	Merker grass (N only)	30164	12640	6557	6083	6075	2676	125	11210
	41	Merker grass (N only)	43595	14871	5637	9234	9107	3829	1400	18260
13	16	Merker grass (N only)	37884	13384	5481	7903	6757	3585	3905	18320
	17	Merker grass (N only)	38060	13012	5333	7679	7283	3265	535	14280
	18	Merker grass (N only)	36107	13384	6219	7165	6626	3208	435	14470
	19	Merker grass (N only)	29371	12640	7479	5161	6168	2817	265	11940
	20	Merker grass (N only)	36447	13384	6710	6674	9224	3309	2450	14415
	21	Merker grass (N only)	33846	12826	6429	6397	5170	3188	485	14875
14	1	Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1	23757	10496	4611	5885	6737	2898	95	8180
	3	Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1	27919	11185	4512	6673	9192	3393	440	6230
	4	Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1	27486	11185	4702	6483	7122	3251	455	10420
	5	Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1	28478	11300	4472	6828	10114	3415	1250	8645
	6	Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1	25670	10841	4933	5908	6750	2888	515	8155
	41	Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1	40726	13995	4306	9689	10725	4503	2180	17115

TABLE II

PER CENT NITROGEN IN FEED FED, REFUSE LEFT, FECES AND URINE

(FEED, REFUSE AND FECES ANALYSES, PER CENT ON DRY BASIS)

(URINE ANALYSES, PER CENT BY VOLUME)

Trial No.	Ration	Nitrogen in feed fed %	Nitrogen in refuse left %	Animal No.	Nitrogen in feces %	Nitrogen in urine %
3......	Soy bean (in flower) Otootan.. variety	2.42	1.64	16	1.71	0.37
				17	1.84	0.61
				18	1.93	0.60
				20	1.90	0.65
				21	2.00	0.54
4......	Soy bean (in flower) Otootan.. variety	2.66	1.62	40	1.70	0.56
				41	1.67	0.54
				42	1.86	0.57
				43	1.70	0.53
				44	1.71	0.53
5......	Soy bean (in full pods)...... Otootan variety	2.60	1.55	16	1.83	0.42
				17	1.97	0.82
				18	2.13	0.83
				20	1.98	1.07
				21	2.40	0.92
6......	Soy bean (in full pods)...... Otootan variety	2.58	1.61	40	1.91	0.79
				41	2.11	0.95
				42	2.16	1.05
				43	1.84	1.00
				44	1.98	1.29
7......	Velvet bean (in flower)......	2.48	1.67	16	2.23	0.45
				18	2.45	0.52
				20	2.40	0.65
				21	2.64	0.52
8......	Velvet bean (in flower)......	2.53	1.67	40	2.69	0.74
				41	2.99	0.68
				42	2.61	0.65
				44	2.63	0.78
9......	Velvet bean (full pods) NPK.	2.61	2.05	16	3.36	0.41
				17	3.58	0.45
				18	3.36	0.45
				19	3.06	0.41
				20	3.57	0.41
				21	3.69	0.53
10......	Pigeon peas (before blooming). N-P-K	3.42	3.57	1	2.87	1.42
				3	2.69	2.12
				4	2.83	1.58
				40	2.55	1.35
				41	2.56	1.17
11......	Pigeon peas (before blooming). N-P-K	3.05	3.05	16	2.61	1.07
				17	2.74	1.67
				18	2.83	1.86
				19	2.72	1.24
				20	2.44	1.92
				21	2.81	1.35
2......	Yaragua—N and P..........	0.80	0.44	40	1.22	0.19
				41	1.34	0.12
				42	1.37	0.24
				43	1.21	0.20
				44	1.31	0.19
12......	Merker grass (N only).......	1.80	1.33	1	1.92	0.55
				3	2.16	0.66
				4	1.85	0.45
				40	1.80	0.49
				41	1.67	0.46
13......	Merker grass (N only).......	1.56	1.05	16	1.38	0.34
				17	1.47	0.39
				18	1.49	0.40
				19	1.40	0.42
				20	1.38	0.35
				21	1.41	0.45
14......	Merker grass (N only) 1¼.... Pigeon peas (before blooming) 1	1.97	1.16	1	2.50	0.56
				3	2.40	0.71
				4	2.51	0.48
				5	2.42	0.71
				6	2.57	0.58

TABLE III

MAINTENANCE REQUIREMENT OF LAMBS AVERAGING 16.96 KILOGRAMS IN WEIGHT, BODY NITROGEN IN FECES PER GRAM OF DRY MATTER INGESTED, AND BODY NITROGEN IN URINE PER KILOGRAM OF BODY WEIGHT, BASED ON TEN-DAY TRIALS DURING WHICH NEARLY NITROGEN-FREE RATIONS WERE FED

Remarks	Lamb No.	Body Nitrogen in Feces Per Gram of Dry Matter Ingested	Average Body Nitrogen in Feces Per Gram of Dry Matter Ingested	Body Nitrogen in Urine Per Kilogram of Body Weight	Average Body Nitrogen in Urine Per Kilogram of Body Weight
Value obtained in the year 1936 to 1937	1A	0.0041	....	0.535	....
	2A	0.0051	....	0.372	....
	3A	0.0036	....	0.441	....
	1B	0.0038	....	0.830	....
	2B	0.0046	....	0.626	....
	3B	0.0046	0.0043	0.565	0.561

TABLE IV

SUMMARY OF METABOLISM EXPERIMENTS UPON WHICH THE DETERMINATION OF BIOLOGICAL VALUES OF PROTEINS IN THE LEGUMES AND GRASSES IS BASED

Trial No.	Ration	Animal No.	Body Weight: Initial Kg.	Body Weight: Final Kg.	Body Weight: Average Kg.	Feed intake Wet-Gm.	Feed intake Dry-Gm.	Nitrogen Intake-Gm.	Total fecal nitrogen-Gm.	Body nitrogen in feces-Gm.	Food nitrogen in feces-Gm.	Absorbed nitrogen-Gm.	Total nitrogen in urine-Gm.	Body nitrogen in urine-Gm.	Food nitrogen in urine-Gm.	Food nitrogen retained-Gm.	Biological value	Average biological value
3..	Soy bean (in flower).....	16	15.42	13.83	14.63	35,250	5,330	147.18	36.05	22.92	13.13	134.05	91.59	7.70	83.89	50.16	37	....
		17	15.42	15.08	15.25	39,148	5,977	160.11	43.53	25.70	17.83	142.28	116.91	8.02	108.89	33.39	24	....
		18	12.81	13.95	13.38	33,904	5,128	142.18	39.45	22.05	17.40	124.78	89.16	7.04	82.12	42.66	34	32
		20	17.05	17.58	17.32	39,010	5,886	159.77	45.79	25.31	20.48	139.29	100.13	9.11	91.02	48.27	35	....
		21	16.95	16.22	16.59	32,529	4,606	133.56	38.20	19.81	18.39	115.17	88.64	8.73	79.91	35.26	31	....
4..	Soy bean (in flower)..... Ototan variety	40	17.35	17.58	17.47	45,250	6,716	199.66	47.02	28.88	18.14	181.52	102.12	9.19	92.93	88.59	49	....
		41	15.76	15.76	15.76	48,553	7,206	215.41	51.79	30.99	20.80	194.61	128.95	8.29	120.66	73.95	38	....
		42	21.66	22.91	22.28	40,665	5,713	183.41	44.44	24.57	19.87	163.54	116.48	11.72	104.76	58.78	36	43
		43	21.66	22.00	21.83	45,272	6,518	196.45	43.67	28.03	15.64	180.81	112.12	11.48	100.64	80.17	44	....
		44	18.26	19.28	18.77	44,743	6,597	197.73	45.69	28.37	17.32	180.41	100.44	9.87	90.57	89.84	50	....
5..	Soy bean (full pods)..... Ototan variety	16	13.72	15.04	14.38	30,729	6,611	215.75	43.55	28.43	15.12	200.63	86.58	7.56	79.02	121.61	61	....
		17	15.76	17.69	16.73	35,616	7,958	249.96	57.00	34.22	22.78	227.18	113.78	8.80	104.98	122.20	54	....
		18	13.49	15.08	14.29	24.960	5,807	203.29	36.79	24.97	11.82	191.47	77.02	7.52	69.50	121.97	64	62
		20	17.12	17.24	17.18	27,959	6,232	209.88	41.44	26.80	14.64	195.24	61.20	9.04	52.16	143.08	73	....
		21	14.86	15.76	15.31	25,411	5,565	199.54	43.46	23.93	19.53	180.01	85.24	8.05	77.19	102.82	57	....
6..	Soy bean (full pods)..... Ototan variety	40	17.60	17.58	17.64	29,746	6,944	243.95	45.46	29.86	15.60	228.35	69.48	9.28	60.20	168.15	74	....
		41	16.44	16.90	16.67	32,000	7,870	258.86	62.39	33.84	28.55	230.31	113.15	8.77	104.38	125.93	55	....
		42	22.23	23.59	22.91	32,254	7,499	252.89	58.19	32.25	25.94	226.95	96.39	12.05	84.34	142.61	63	63
		43	23.59	23.70	23.65	34,150	7,683	255.85	59.65	33.04	26.61	229.24	105.40	12.44	92.96	136.28	60	....
		44	19.73	19.73	19.73	31,405	7,434	251.84	56.09	31.97	24.12	227.72	92.30	10.38	81.92	145.80	64	....
7..	Velvet bean (in flower)...	16	15.88	16.33	16.11	36,859	6,626	192.23	47.66	28.49	19.17	173.06	84.62	8.47	76.15	96.91	56	....
		18	15.19	16.33	15.76	34,685	6,540	190.79	48.41	28.12	20.29	170.50	88.61	8.29	80.32	90.18	53	54
		20	17.92	18.71	18.32	35,146	6,370	188.02	47.18	27.41	19.77	168.25	84.34	9.64	74.70	93.55	56	....
		21	15.65	16.33	15.99	31,699	5,753	177.65	46.70	24.74	21.96	155.69	83.49	8.41	75.08	80.61	52	....
8..	Velvet bean (in flower)...	40	17.46	18.37	17.92	30,447	5,742	185.91	48.66	24.69	23.97	161.94	65.27	9.43	55.84	106.10	66	....
		41	17.35	17.46	17.41	38,037	6,768	203.05	81.57	29.10	52.47	150.58	96.49	9.16	87.33	63.25	41	52
		42	23.59	25.06	24.33	39,940	7,300	211.93	67.13	31.39	35.74	176.19	99.87	12.80	87.07	89.12	51	....
		44	20.53	20.98	20.76	36,736	6,611	200.42	59.04	28.43	30.61	169.81	94.73	10.92	83.81	86.00	51	....

9..	Velvet bean (full pods)... NPK	16	16.10	16.78	16.44	34,766	6,634	199.80	54.97	28.53	26.44	173.36	79.31	8.65	70.66	102.70	59	....
		17	17.35	17.92	17.64	41,187	8,264	241.72	91.00	35.54	55.46	186.26	68.85	9.28	59.57	126.69	68	....
		18	14.76	15.88	15.32	31,045	6,133	189.53	57.19	26.37	30.82	158.71	72.41	8.06	64.35	94.36	60	63
		19	12.13	13.15	12.64	33,676	6,569	198.47	54.99	28.25	26.74	171.73	72.43	6.65	65.78	105.95	62	....
		20	18.94	18.60	18.77	37,671	7,483	220.39	68.69	32.18	36.51	183.88	59.98	9.87	50.11	133.77	73	....
		21	15.31	16.56	15.97	32,098	6,163	190.14	45.39	26.50	18.89	171.25	81.73	8.38	73.35	97.90	57	....
10..	Pigeon peas.............. (before blooming) NPK	1	11.11	11.23	11.17	20,008	4,169	132.26	56.94	17.93	39.01	93.25	73.41	5.88	67.53	25.72	28	....
		3	13.83	14.63	14.23	19,830	4,588	147,22	59.99	19.73	40.26	106.96	73.56	7.48	66.08	40.88	38	....
		4	12.47	13.15	12.81	21,937	4,634	148.96	64.84	19.93	44.91	104.05	81.05	6.74	74.31	29.74	29	40
		40	17.01	18.26	17.64	19,370	4,181	132.69	46.10	17.98	28.12	104.57	39.83	9.28	30.55	74.02	71	....
		41	19.39	20.75	20.07	29,569	6,665	219.71	83.25	28.66	54.59	165.12	123.38	10.56	112.82	52.30	32	....
11..	Pigeon peas.............. (before blooming) NPK	16	18.26	20.53	19.40	27,832	6,234	190.14	68.90	26.81	42.09	148.05	74.47	10.20	64.27	83.78	57	....
		17	18.94	21.89	20.42	28,917	6,886	210.02	80.72	29.61	51.11	158.91	103.04	10.74	92.30	66.61	42	....
		18	17.12	19.39	18.26	25,087	6,003	183.09	70.67	25.81	44.86	138.23	83.24	9.60	73.64	64.59	47	49
		19	13.49	14.74	14.12	23,280	5,755	175.53	62.26	24.75	37.51	138.02	77.75	7.43	70.32	67.70	49	....
		20	19.50	20.53	20.02	22,372	5,314	162.08	49.90	22.85	27.05	135.03	61.54	10.53	51.01	84.02	62	....
		21	17.46	19.96	18.71	25,519	6,090	185.75	68.68	26.19	42.49	143.26	101.66	9.84	91.82	51.44	36	....
2..	Yaraguá (N and P)......	40	18.90	19.05	18.98	26,860	6,045	62.91	36.10	25.99	10.11	52.80	13.23	9.98	3.25	49.55	94	....
		41	17.43	18.03	17.73	19,667	4,483	53.95	30.40	19.28	11.12	42.83	18.56	9.33	9.29	33.60	78	....
		43	22.03	22.79	22.41	26,945	5,716	62.29	37.43	24.58	12.85	49.44	17.06	11.79	5.27	44.17	89	84
		42	22.88	23.81	23.35	21,685	4,973	56.11	33.24	21.38	11.86	44.25	24.13	12.28	11.85	32.40	73	....
		44	17.65	19.16	18.41	22,457	5,071	56.95	32.27	21.81	10.46	46.49	16.99	9.68	7.31	39.18	84	....
12..	Merker grass (N only)...	1	10.55	10.77	10.66	24,543	5,148	120.88	40.95	22.14	18.81	102.07	45.49	7.61	39.88	62.19	61	....
		3	13.49	14.63	14.06	27,010	6,198	138.35	51.88	26.65	25.23	113.12	45.08	7.40	37.68	75.44	67	....
		4	12.81	13.83	13.32	28,276	6,071	136.66	47.95	26.11	21.84	114.82	51.66	7.01	44.65	70.17	61	61
		40	17.01	18.26	17.64	30,164	6,083	140.31	48.17	26.16	22.01	118.30	54.93	9.28	45.65	72.65	61	....
		41	19.28	19.96	19.62	43,595	9,234	192.71	63.94	39.71	24.23	168.48	84.00	10.32	73.68	94.80	56	....
13..	Merker grass (N only)...	16	19.05	20.41	19.73	37,884	7,903	151.24	49.47	33.98	15.49	135.75	62.29	10.38	51.91	83.84	62	....
		17	19.96	20.87	20.42	38,060	7,679	146.99	48.00	33.02	14.98	132.01	55.69	10.74	44.95	87.06	66	....
		18	18.94	20.87	19.91	36,107	7,165	143.49	47.80	31.81	16.99	126.50	57.88	10.47	47.41	79.09	62	63
		19	14.29	14.51	14.40	29,371	5,161	118.65	39.44	22.19	17.25	101.40	50.15	7.57	42.58	58.82	58	....
		20	21.89	22.00	21.94	36,447	6,674	138.33	45.66	28.70	16.96	121.37	50.45	11.54	38.91	82.46	68	....
		21	19.39	20.41	19.90	33,846	6,397	132.59	44.95	27.51	17.44	115.15	56.92	10.47	46.45	68.70	60	....
14..	Merker grass (N only) 1 ¼ +Pigeon pea (before blooming) 1	1	12.25	11.79	12.02	23,757	5,885	153.28	72.45	25.31	47.14	106.14	45.81	6.32	39.49	66.65	63	....
		3	14.97	14.97	14.97	27,919	6,673	168.00	81.43	28.69	52.74	115.26	44.23	7.87	36.36	78.90	68	....
		4	15.08	14.63	14.86	27,486	6,483	165.80	81.60	27.88	53.72	112.08	50.02	7.82	42.20	69.88	62	63
		5	18.14	17.69	17.92	28,478	6,828	170.73	82.64	29.36	53.28	117.45	61.38	9.43	51.95	65.50	56	....
		6	19.39	18.71	19.05	25,670	5,908	156.35	74.22	25.40	48.82	107.53	47.30	10.02	37.28	70.25	65	....
		41	22.68	22.57	22.63	40,726	9,689	225.75	100.42	41.66	58.76	166.99	77.02	11.90	65.12	101.87	61	....

TABLE V

ANALYSES OF GRASSES AND LEGUMES FED

WET BASIS

Trial No.	Item	Total moisture %	Crude protein (N x 6.25) %	Ether-soluble extract-%	Crude fiber %	Carbohydrates %	Ash %	Calcium %	Phosphorus %
3....	Soy bean (in flower) Otootan var. N-P-K...	83.60	2.48	0.60	5.36	6.05	1.91	0.233	0.0424
4....	Soy bean (in flower) Otootan var. N-P-K...	83.95	2.67	0.46	4.98	6.05	1.89	0.236	0.0403
5....	Soy bean (full pods) Otootan var. N-P-K...	76.68	3.79	1.32	7.23	8.52	2.46	0.287	0.0606
6....	Soy bean (full pods) Otootan var. N-P-K...	74.97	4.04	1.56	7.42	9.03	2.98	0.305	0.0615
7....	Velvet bean (in flower) N-P-K................	80.86	2.97	0.82	6.58	7.71	1.06	0.232	0.0256
8....	Velvet bean (in flower) N-P-K................	80.77	3.04	0.79	6.64	7.60	1.16	0.233	0.0367
9....	Velvet bean (full pods) N-P-K................	79.07	3.42	0.48	5.85	9.81	1.37	0.213	0.0379
10....	Pigeon peas (before blooming) N-P-K......	75.64	5.21	1.46	7.49	8.79	1.41	0.217	0.0590
11....	Pigeon peas (before blooming) N-P-K......	74.21	4.92	1.43	7.88	10.07	1.49	0.245	0.0526
1....	Yaragua (N and P)......	75.18	1.15	0.66	9.63	11.56	1.82	0.0779	0.0437
2....	Yaragua (N and P)......	74.44	1.28	0.77	10.10	11.42	1.99	0.0832	0.0518
12....	Merker grass (N only)...	79.51	2.31	0.72	6.52	8.56	2.38	0.079	0.0320
13....	Merker grass (N only)...	79.51	2.00	0.71	6.64	8.80	2.34	0.060	0.0322
14....	Merker grass (N only) 1¼ plus pigeon peas (before blooming) 1.....	74.71	3.11	0.99	8.45	10.75	1.99	0.177	0.0448

TABLE VI

ANALYSES OF GRASSES AND LEGUMES FED

DRY BASIS

Trial No.	Item	Total solids %	Crude protein (N x 6.25) %	Ether-soluble extract–%	Crude fiber %	Carhydrates %	Ash %	Calcium %	Phosphorus %
3....	Soy bean (in flower) Otootan var. N-P-K...	16.40	15.13	3.63	32.70	36.88	11.66	1.42	0.259
4....	Soy bean (in flower) Otootan var. N-P-K...	16.05	16.63	2.84	31.05	37.70	11.78	1.47	0.251
5....	Soy bean (full pods) Otootan var. N-P-K...	23.32	16.25	5.65	31.00	36.57	10.53	1.23	0.260
6....	Soy bean (full pods) Otootan var. N-P-K...	25.03	16.12	6.22	29.65	36.11	11.90	1.22	0.245
7....	Velvet bean (in flower) N-P-K................	19.14	15.51	4.27	34.38	40.29	5.55	1.21	0.134
8....	Velvet bean (in flower) N-P-K................	19.23	15.80	4.10	34.56	39.53	6.01	1.21	0.191
9....	Velvet bean (full pods) N-P-K................	20.93	16.36	2.31	27.95	46.84	6.54	1.02	0.181
10....	Pigeon peas (before blooming) N-P-K......	24.36	21.38	6.00	30.75	36.11	5.76	0.89	0.242
11....	Pigeon peas (before blooming) N-P-K......	25.79	19.06	5.53	30.55	39.07	5.79	0.95	0.204
1....	Yaragua (N and P)......	24.82	4.63	2.64	38.80	46.61	7.32	0.314	0.176
2....	Yaragua (N and P)......	25.56	5.00	3.03	39.50	44.74	7.77	0.326	0.203
12....	Merker grass (N only)...	20.49	11.25	3.52	31.80	41.82	11.61	0.378	0.156
13....	Merker grass (N only)...	20.49	9.75	3.47	32.40	42.98	11.43	0.294	0.157
14....	Merker grass (N only) 1¼ plus pigeon peas (before blooming) 1.....	25.29	12.30	3.91	33.45	42.49	7.85	0.70	0.177

TABLE VII

PROXIMATE ANALYSES, REPORTED ON DRY BASIS, OF THE FED AND REFUSED PORTIONS OF THE RATIONS USED IN THE DIFFERENT METABOLISM EXPERIMENTS

Trial No.	Item	Total solids %		Crude protein (N x 6.25) %		Ether-soluble extract %		Crude fiber %		Carbohydrate %		Ash %		Calcium %		Phosphorus %	
		Feed fed	Refuse left	Feed fed	Refuse left	Feed fed	Refuse left	Feed fed	Refuse left	Feed fed	Refuse lefy	Feed fed	Refuse left	Feed fed	Refuse left	Feed fed	Refuse left
3.....	Soy bean (in flower) Otootan variety N-P-K......	16.40	21.00	15.13	10.25	3.63	1.92	32.70	43.50	36.88	31.73	11.66	12.60	1.42	1.21	0.259	0.194
4.....	Soy bean (in flower) Otootan variety N-P-K......	16.05	22.36	16.63	10.13	2.84	1.31	31.05	43.50	37.70	32.76	11.78	12.30	1.47	1.19	0.251	0.192
5.....	Soy bean (full pods) Otootan variety N-P-K......	23.32	25.14	16.25	9.69	5.65	2.66	31.00	41.55	36.57	34.75	10.53	11.35	1.23	1.24	0.260	0.173
6.....	Soy bean (full pods) Otootan variety N-P-K......	25.03	27.30	16.12	10.06	6.22	1.21	29.65	41.50	36.11	35.22	11.90	12.01	1.22	1.21	0.245	0.172
7.....	Velvet bean (in flower) N-P-K	19.14	20.84	15.51	10.43	4.27	2.12	34.38	44.40	40.29	37.83	5.55	5.22	1.21	1.04	0.134	0.117
8.....	Velvet bean (in flower) N-P-K	19.23	21.48	15.80	10.43	4.10	1.23	34.56	45.50	39.53	37.10	6.01	5.74	1.21	1.06	0.191	0.151
9.....	Velvet bean (full pods) N-P-K	20.93	23.17	16.36	12.81	2.31	2.13	27.95	40.40	46.84	35.39	6.54	9.27	1.02	1.56	0.181	0.148
10.....	Pigeon peas (before blooming) N-P-K...........	24.36	26.39	21.38	22.31	6.00	5.25	30.75	33.05	36.11	32.90	5.76	6.49	0.89	0.91	0.242	0.260
11.....	Pigeon peas (before blooming) N-P-K...........	25.79	27.66	19.06	19.06	5.53	4.39	30.55	34.54	39.07	36.15	5.79	5.86	0.95	0.89	0.204	0.205
1.....	Yaragua (N and P)...........	24.82	28.14	4.63	2.88	2.64	1.88	38.80	46.90	46.61	41.94	7.32	6.40	0.314	0.214	0.176	0.114
2.....	Yaragua (N and P)...........	25.56	30.84	5.00	2.75	3.03	1.72	39.50	46.63	44.74	42.50	7.77	6.40	0.326	0.164	0.203	0.138
12.....	Merker grass (N only).........	20.49	19.65	11.25	8.31	3.52	2.31	31.80	35.95	41.82	42.78	11.61	10.65	0.378	0.32	0.156	0.148
13.....	Merker grass (N only).........	20.49	21.83	9.75	6.56	3.47	2.30	32.40	37.80	42.98	43.54	11.43	9.80	0.294	0.21	0.157	0.135
14.....	Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1	25.29	27.85	12.30	7.25	3.91	2.49	33.45	43.93	42.49	40.75	7.85	5.58	0.70	0.54	0.177	0.165

TABLE VIII

APPROXIMATE ANALYSES OF FECES—DRY BASIS

Trial No.	Item	Animal No.	Total solids %	Crude protein (N x 6.25) %	Ether soluble extract %	Crude fiber %	Carbo-hydrate %	Ash %	Calcium %	Phosphorus %
3...	Soy bean (in flower) Otootan variety K-P-K......	16	40.44	10.69	4.32	30.86	26.43	27.70	4.08	0.723
	Soy bean (in flower) Otootan variety N-P-K......	17	41.16	11.50	3.91	29.20	25.29	30.10	4.08	0.716
	Soy bean (in flower) Otootan variety N-P-K......	18	46.65	12.06	4.22	26.66	27.96	29.10	4.04	0.678
	Soy bean (in flower) Otootan variety N-P-K......	20	28.79	11.88	4.52	28.00	25.62	29.98	3.82	0.698
	Soy bean (in flower) Otootan variety N-P-K......	21	45.31	12.50	4.73	27.50	26.12	29.15	4.07	0.767
4...	Soy bean (in flower) Otootan variety K-P-K......	40	25.51	10.63	4.16	28.35	26.71	30.15	3.24	0.546
	Soy bean (in flower) Otootan variety K-P-K......	41	33.04	10.44	4.28	28.70	25.88	30.70	3.30	0.547
	Soy bean (in flower) Otootan variety K-P-K......	42	37.79	11.63	4.12	24.20	25.22	34.83	4.03	0.676
	Soy bean (in flower) Otootan variety K-P-K......	43	35.02	10.63	3.60	29.00	25.71	31.06	3.65	0.513
	Soy bean (in flower) Otootan variety N-P-K......	44	30.57	10.69	3.91	29.50	24.60	31.30	3.72	0.482
5...	Soy bean (full pods) Otootan variety N-P-K......	16	31.83	11.44	4.73	33.60	29.60	20.63	2.80	0.640
	Soy bean (full pods) Otootan variety N-P-K......	17	40.29	12.31	5.18	26.00	31.26	25.25	3.25	0.653
	Soy bean (full pods) Otootan variety N-P-K......	18	51.92	13.31	4.88	24.90	31.06	25.85	3.26	0.861
	Soy bean (full pods) Otootan variety N-P-K......	20	25.04	12.38	4.24	27.05	32.18	24.15	2.90	0.758
	Soy bean (full pods) Otootan variety N-P-K......	21	43.92	15.00	4.89	29.00	28.36	22.75	3.26	0.820
6...	Soy bean (full pods) Otootan variety N-P-K......	40	27.65	11.94	4.68	25.71	31.84	25.83	2.56	0.750
	Soy bean (full pods) Otootan variety N-P-K......	41	28.58	13.19	4.84	23.50	34.76	23.71	2.54	0.683
	Soy bean (full pods) Otootan variety N-P-K......	42	26.32	13.50	4.66	23.50	30.34	28.00	3.12	0.745
	Soy bean (full pods) Otootan variety N-P-K......	43	36.11	11.50	4.32	26.30	29.28	28.60	3.03	0.718
	Soy bean)full pods(Otootan variety N-P-K......	44	27.13	12.80	5.18	24.55	31.99	25.48	2.85	0.765
7...	Velvet bean (in flower).............. N-P-K......	16	29.44	13.93	5.14	40.60	29.25	11.08	2.98	0.437
	Velvet bean (in flower).............. N-P-K......	18	48.70	15.30	6.39	40.40	27.41	10.50	3.06	0.394
	Velvet bean (in flower).............. N-P-K......	20	28.77	15.00	5.82	39.25	28.00	11.93	3.08	0.448
	Velvet bean (in flower).............. N-P-K......	21	50.45	16.50	6.43	37.20	29.49	10.38	3.14	0.457
8...	Velvet bean (in flower).............. N-P-K......	40	28.09	16.80	5.55	37.50	26.80	13.35	3.02	0.517
	Velvet bean (in flower).............. N-P-K......	41	26.19	18.70	5.80	36.00	27.83	11.67	2.79	0.565
	Velvet bean (in flower).............. N-P-K......	42	29.10	16.31	5.22	37.15	29.48	11.84	2.80	0.502
	Velvet bean (in flower).............. N-P-K......	44	25.12	16.42	5.18	35.20	30.57	12.63	3.25	0.546
9...	Velvet bean (in full pods)............ N-P-K......	16	32.49	21.00	2.75	30.26	33.84	12.15	2.27	0.474
	Velvet bean (in full pods)............ N-P-K......	17	25.81	22.38	2.56	28.15	33.83	13.08	2.49	0.674
	Velvet bean (in full pods)............ N-P-K......	18	33.74	21.00	2.92	30.10	33.48	12.50	2.36	0.556
	Velvet bean (in full pods)............ N-P K......	19	36.17	19.13	2.90	32.35	32.46	13.16	2.42	0.597
	Velvet bean (in full pods)............ N-P-K......	20	22.61	22.33	2.81	28.85	32.38	13.63	2.23	0.606
	Velvet bean (in full pods)............ N-P-K......	21	33.81	23.06	2.82	29.80	32.41	11.91	2.25	0.637

10...	Pigeon peas (before blooming) N-P-K	1	39.53	17.94	6.56	35.40	29.88	10.22	2.32	0.486
	Pigeon peas (before blooming) N-P-K	3	34.58	16.81	5.22	38.80	29.34	9.83	2.01	0.457
	Pigeon peas (before blooming) N-P-K	4	33.51	17.69	6.91	34.67	31.04	9.69	2.02	0.498
	Pigeon peas (before blooming) N-P-K	40	24.52	15.94	6.10	38.05	29.43	10.48	2.04	0.388
	Pigeon peas (before blooming) N-P-K	41	33.52	16.01	5.72	38.31	30.21	9.75	2.08	0.418
11...	Pigeon peas (before blooming) N-P-K	16	28.50	16.31	6.38	40.45	27.50	9.36	1.97	0.326
	Pigeon peas (before blooming) N-P-K	17	32.68	17.12	5.81	42.65	24.56	9.86	2.10	0.364
	Pigeon peas (before blooming) N-P-K	18	28.81	17.69	6.31	35.09	30.61	10.30	1.98	0.328
	Pigeon peas (before blooming) N-P-K	19	31.32	17.00	6.72	36.25	29.70	10.33	2.18	0.407
	Pigeon peas (before blooming) N-P-K	20	22.34	15.25	5.97	36.16	31.37	11.25	2.26	0.462
	Pigeon peas (before blooming) N-P-K	21	36.25	17.56	6.85	34.70	31.10	9.79	2.27	0.399
2...	Yaragua (N and P)	40	34.00	7.63	3.82	27.85	45.25	15.45	0.89	0.448
	Yaragua (N and P)	41	53.57	8.38	3.54	26.00	46.43	15.65	0.987	0.514
	Yaragua (N and P)	42	50.26	8.56	3.83	23.70	46.41	17.50	1.06	0.555
	Yaragua (N and P)	43	34.22	7.56	4.23	27.40	45.89	14.92	0.864	0.433
	Yaragua (N and P)	44	48.59	8.19	4.18	25.00	45.59	17.04	1.04	0.578
12...	Merker grass (N only)	1	46.66	12.00	5.80	22.85	35.90	23.45	1.28	0.469
	Merker grass (N only)	3	30.17	13.50	5.39	22.00	35.86	23.25	1.37	0.486
	Merker grass (N only)	4	47.43	11.56	4.99	25.00	36.15	22.30	1.19	0.426
	Merker grass (N only)	40	45.04	11.25	4.69	22.40	37.36	24.30	1.20	0.562
	Merker grass (N only)	41	42.20	10.44	4.21	23.65	40.00	21.70	0.97	0.426
13...	Merker grass (N only)	16	53.43	8.63	4.46	26.15	38.91	21.85	0.95	0.424
	Merker grass (N only)	17	45.89	9.19	4.64	24.25	39.24	22.68	0.98	0.443
	Merker grass (N only)	18	48.90	9.31	4.33	24.90	38.66	22.80	0.94	0.478
	Merker grass (N only)	19	46.19	8.75	4.71	23.05	40.64	22.85	1.01	0.494
	Merker grass (N only)	20	36.14	8.63	3.85	23.25	41.12	23.15	1.03	0.428
	Merker grass (N only)	21	62.88	8.81	4.19	24.25	40.72	22.03	1.04	0.482
14...	Merker grass (N only) 1¼ + pigeon pea (b.b.*) 1	1	43.20	15.62	5.11	32.78	31.41	15.08	1.06	0.350
	Merker grass (N only) 1¼ + pigeon pea (b.b.*) 1	3	37.07	15.00	4.45	32.60	33.09	14.86	1.14	0.351
	Merker grass (N only) 1¼ + pigeon pea (b.b.*) 1	4	46.01	15.70	5.46	30.48	32.88	15.48	1.17	0.387
	Merker grass (N only) 1¼ + pigeon pea (b.b.*) 1	5	34.01	15.12	5.33	32.35	31.88	15.32	1.14	0.394
	Merker grass (N only) 1¼ + pigeon pea (b.b.*) 1	6	43.18	16.08	5.68	29.75	32.79	15.70	1.18	0.438
	Merker grass (N only) 1¼ + pigeon pea (b.b.*) 1	41	42.23	13.93	4.80	30.97	34.89	15.41	1.10	0.413

* Before blooming.

TABLE IX

INDIVIDUAL COEFFICIENTS OF APPARENT DIGESTIBILITY AND AVERAGES

Trial No.	Ration	Animal No.	Dates on which samples were collected	Coefficients of apparent digestibility						Biological value
				Dry matter	Crude protein	Ether-soluble extract	Carbohydrates		Organic matter	
							Crude fiber	N-free extract		
3...	Soy bean (in flower) Otootan variety...... N-P-K	16	Oct. 12 to Nov. 1..	60	76	61	56	73	68	37
		17		60	73	63	60	74	69	24
		18		60	73	62	62	72	68	34
		20		59	72	57	59	73	68	35
		21		59	72	58	56	73	67	31
			AVERAGE....	60	73	60	59	73	68	32
4...	Soy bean (in flower) Otootan variety...... N-P-K	40	Nov. 1 to Nov. 11	59	75	48	57	73	66	49
		41		57	76	44	54	72	66	38
		42		58	76	53	59	74	69	36
		43		61	78	58	57	74	69	44
		44		60	77	53	56	75	68	50
			AVERAGE....	59	76	51	57	74	68	43
5...	Soy bean (in full pods) N-P-K	16	Nov. 11 to Nov. 21	64	80	77	50	72	68	61
		17		64	78	74	63	70	70	54
		18		70	82	82	66	76	79	64
		20		66	82	82	61	71	72	73
		21		67	78	81	55	76	72	57
			AVERAGE....	66	80	79	59	73	72	62
6...	Soy bean (in full pods) N-P-K...........	40	Nov. 21 to Dec. 1	66	81	86	52	70	71	74
		41		62	76	82	58	65	68	55
		42		64	77	84	58	70	71	63
		43		57	76	82	45	65	66	60
		44		62	77	81	53	67	68	64
			AVERAGE....	62	77	83	53	67	69	63
7...	Velvet bean (in flower) N-P-K...........	16	Dec. 1 to Dec. 11..	68	75	69	55	77	70	56
		18		70	75	65	59	80	71	53
		20		69	75	68	58	80	71	56
		21		69	74	66	57	78	71	52
			AVERAGE....	69	75	67	57	79	71	54
8...	Velvet bean (in flower) N-P-K...........	40	Dec. 11 to Dec. 21.	68	74	73	66	80	71	66
		41		60	60	59	49	73	62	41
		42		65	68	65	56	74	67	51
		44		66	70	69	58	75	68	51
			AVERAGE....	65	68	67	57	76	67	52

9...	Velvet bean (full pods) N-P-K...........	16	Jan. 12 to Jan. 22..	75	73	72	61	85	77	59
		17		69	63	67	59	81	72	68
		18		72	70	67	52	84	75	60
		19		73	72	68	53	84	75	62
		20		74	69	70	64	85	77	73
		21		80	76	77	66	89	81	57
			AVERAGE....	74	71	70	59	85	76	63
10...	Pigeon peas (before blooming) N-P-K.....	1	Feb. 1 to Feb. 11..	52	57	57	38	66	55	28
		3		51	59	64	31	65	54	38
		4		51	57	52	38	62	53	29
		40		57	65	64	39	69	59	71
		41		51	62	58	35	62	54	32
			AVERAGE....	52	60	59	36	65	55	40
11...	Pigeon peas (before blooming) N-P-K.....	16	Feb. 11 to Feb. 21.	58	64	61	33	73	59	57
		17		57	60	63	31	75	59	42
		18		58	61	63	42	70	61	47
		19		60	65	63	42	73	62	49
		20		62	69	69	42	72	64	62
		21		60	63	61	45	71	62	36
			AVERAGE....	59	64	63	39	72	61	49
2...	Yaragua (N and P).......................	40	Oct. 12 to Oct. 22..	56	43	52	61	52	55	94
		41		49	44	43	58	50	53	78
		42		51	41	51	65	51	56	73
		43		46	40	44	56	47	50	89
		44		51	43	52	63	53	55	84
			AVERAGE....	51	42	48	61	51	54	84
12...	Merker grass (N only)....................	1	Feb. 21 to Mar. 3..	59	66	51	65	63	64	61
		3		61	63	55	69	66	66	67
		4		57	65	55	62	62	62	61
		40		56	66	57	64	60	62	61
		41		59	67	59	68	60	63	56
			AVERAGE....	58	65	55	66	62	63	61
13...	Merker grass (N only)....................	16	Mar. 4 to Mar. 14..	55	58	53	59	59	59	62
		17		57	67	55	64	61	62	66
		18		55	67	57	59	59	60	62
		19		45	67	50	49	43	51	58
		20		50	67	59	57	52	56	68
		21		50	66	58	55	52	55	60
			AVERAGE....	52	65	55	57	54	57	63
14...	Merker grass (N only) 1¼+ pigeon peas (before blooming) 1.....................	1	Mar. 19 to Mar. 29.	51	53	50	36	65	54	63
		3		49	51	54	37	62	52	68
		4		50	50	44	41	62	53	62
		5		50	52	45	39	64	53	56
		6		51	52	46	41	63	56	65
		41		54	56	51	50	62	57	61
			AVERAGE....	51	52	48	41	63	54	63

TABLE X

DIGESTIBLE NUTRIENTS IN 100 LBS. OF LEGUME AND GRASS FEEDING STUFFS AS CUT

Trial No.	Ration	Total dry matter	Digestible nutrients					Nutritive ratio 1 to
			Crude protein	Carbohydrates		Ether-soluble extract	Total* digestible nutrients	
				Crude fiber	N-free extract			
3	Soy bean (in flower) Ototan var. N-P-K	16.40	1.81	3.16	4.42	0.36	10.20	4.63
4	Soy bean (in flower) Ototan var. N-P-K	16.05	2.03	2.84	4.48	0.23	9.87	3.86
5	Soy bean (full pods) Ototan var. N-P-K	23.32	3.03	4.27	6.22	1.04	15.86	4.23
6	Soy bean (full pods) Ototan var. N-P-K	25.03	3.11	3.93	6.05	1.29	15.99	4.16
7	Velvet bean (in flower) N-P-K	19.14	2.23	3.75	6.09	0.55	13.31	4.97
8	Velvet bean (in flower) N-P-K	19.23	2.07	3.78	5.78	0.53	12.81	5.19
9	Velvet bean (full pods) N-P-K	20.93	2.43	3.45	8.34	0.34	14.99	5.17
10	Pigeon pen (before blooming) N-P-K	24.36	3.13	2.70	5.71	0.86	13.48	3.31
11	Pigeon pea (before blooming) N-P K	25.79	3.15	3.07	7.25	0.90	15.50	3.92
2	Yaragua (N and P)	25.56	0.54	6.16	5.82	0.37	13.35	23.7
12	Merker grass (N only)	20.49	1.50	4.30	5.31	0.40	12.01	7.02
13	Merker grass (N only)	20.49	1.30	3.78	4.75	0.39	10.71	7.23
14	Merker grass (N only) 1¼ + pigeon pea (before blooming) 1	25.29	1.62	3.46	6.77	0.48	12.93	6.98

* Total digestible nutrients including fat x 2.25.

TABLE XI

DIGESTIBLE NUTRIENTS PRODUCED PER CUERDA* OF GREEN LEGUMES**

Trial No.	Ration	Dry matter lbs.	Crude protein (N x 6.25) lbs.	Crude fiber lbs.	Nitrogen-free extract lbs.	Ether-soluble extract lbs.	Total digestible matter lbs.
3.....	Soy bean (in flower) Ototan var..........................	1,968	217	380	530	43	1,224
4.....	Soy bean (in flower) Ototan var..........................	1,926	243	341	537	28	1,184
	AVERAGE..........	1,947	230	361	534	36	1,204
5.....	Soy bean (full pods) Ototan var..........................	3,731	485	682	996	166	2,537
6.....	Soy bean (full pods) Ototan var..........................	4,005	497	629	969	207	2,561
	AVERAGE..........	3,868	491	656	983	187	2,549
7.....	Velvet bean (in flower)......	4,976	579	975	1,502	142	3,376
8.....	Velvet bean (in flower)......	5,000	537	985	1,584	138	3,417
	AVERAGE..........	4,988	558	980	1,543	140	3,397
9.....	Velvet bean (full pods)......	5,860	681	966	2,333	95	4,194
10.....	Pigeon pea (before flowering).	2,436	313	270	572	86	1,349
11.....	Pigeon pea (before flowering).	2,579	315	307	725	90	1,550
	AVERAGE..........	2,508	314	289	648	88	1,450

*One cuerda equals 0.954 acre.
**All fertilized with N-P-K.

TABLE XII

NET PROTEIN VALUES OF COMMON LEGUMES FED SINGLY AND IN COMBINATION TO LAMBS WET BASIS

Trial No.	Ration	Protein in feed consumed per cent	Coefficient of apparent digestibility	Digestible protein per cent	Aver. biological value of digestible protein	Net protein content per cent
3......	Soy bean (in flower) Ototan var......	2.48	73	1.81	32	0.579
4......	Soy bean (in flower) Ototan var......	2.67	76	2.03	43	0.873
	AVERAGE..................	2.58	75	1.92	38	0.726
5......	Soy bean (in full pods) Ototan var...	3.79	80	3.03	62	1.88
6......	Soy bean (in full pods) Ototan var...	4.04	77	3.11	63	1.96
	AVERAGE..................	3.92	79	3.07	63	1.92
7......	Velvet bean (in flower) N-P-K........	2.97	75	2.23	54	1.20
8......	Velvet bean (in flower) N-P-K........	3.04	68	2.07	52	1.08
	AVERAGE..................	3.01	72	2.15	53	1.14
9......	Velvet bean (in full pods) N-P-K.....	3.42	71	2.43	63	1.53
10......	Pigeon pea (before blooming) N-P-K..	5.21	60	3.12	40	1.25
11......	Pigeon pea (before blooming) N-P-K..	4.92	64	3.15	49	1.54
	AVERAGE..................	5.07	62	3.14	45	1.40
14......	Merker grass (N only 1= plus pigeon pea (before blooming) 1.......	3.11	52	1.62	63	1.02

TABLE XIII

YIELD OF CALCIUM AND PHOSPHORUS PER CUERDA AND PER TON OF GREEN LEGUMES

Trial No.	Ration	Green forages per cuerda tons*	Dry legume per cuerda lbs.	Yield per Cuerda of		Yield per Ton of	
				Calcium lbs.	Phosphorus lbs.	Calcium lbs.	Phosphorus lbs.
3....	Soy bean (in flower) Ototan var.	6	1,968	27.95	5.10	4.66	0.85
4....	Soy bean (in flower) Ototan var.	6	1,926	28.31	4.83	4.72	0.81
	AVERAGE............	....	1,947	28.13	4.96	4.69	0.83
5....	Soy bean (full pods) Ototan var..	8	3,731	45.89	9.70	5.74	1.21
6....	Soy bean (full pods) Ototan var..	8	4,005	48.86	9.81	6.11	1.23
	AVERAGE............	....	3,868	47.38	9.75	5.92	1.22
7....	Velvet bean (in flower)..........	13	4,976	60.21	6.67	4.63	0.51
8....	Velvet bean (in flower)..........	13	5,000	60.50	9.55	4.65	0.73
	AVERAGE............	....	4,988	60.36	8.04	4.64	0.62
9....	Velvet bean (full pods)..........	14	5,860	59.77	10.61	4.27	0.76
10....	Pigeon pea (before blooming)....	5	2,436	21.68	5.90	4.34	1.18
11....	Pigeon pea (before blooming)....	5	2,579	24.50	5.26	4.90	1.05
	AVERAGE............	....	2,508	23.09	5.58	4.62	1.11

*Yields obtained at the Experiment Station.

TABLE XIV

VALUE OF THE LEGUMES IN FATTENING

Ration	Average dry matter ingested per head Gms.	Number of animals	Number of days in experiment	Average weight of lamb Kgms.	Increase in weight Kgms.	Increase in weight Per cent
Soy bean (in flower) Ototan var.....	5,968	10	20	18.38	(á) 0.962	(b) 5.23
Soy bean (full pods) Ototan var.....	6,960	10	20	17.44	0.808	4.63
Velvet bean (in flower)...............	6,464	8	20	17.74	0.883	5.02
Velvet bean (full pods)...............	6,874	6	10	15.76	0.717	4.56
Pigeon pea (before blooming).........	5,502	11	20	15.70	1.92	12.22
Merker grass (N only)................	6,701	11	20	17.62	0.246	1.39
Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1....	6,911	6	10	16.12	0.473	2.94

(á)—Average decrease in weight.
(b)—Per cent decrease in weight.

TABLE XV

SUMMARY OF THE NUTRITIVE INDEXES DETERMINED IN THE EXPERIMENTS PERFORMED DURING THE YEAR 1937-38

Ration	Date on which samples were collected	Coefficients of apparent digestibility						Biological value of protein	Net protein value	Nutritive ratio 1 to	P:Ca ratio 1 to
		Dry matter	Crude protein	Crude fat	Crude fiber	N-free extract	Organic matter				
Soy bean (in flower) Ototan var.	Oct. 22 to Nov. 11.	60	75	56	58	74	68	38	0.726	3.75	5.67
Soy bean (full pods) Ototan var.	Nov. 11 to Dec. 1.	64	79	81	56	70	71	63	1.92	4.19	4.84
Velvet bean (in flower) N-P-K	Dec. 1 to Dec. 21.	67	72	67	57	78	69	53	1.14	5.09	7.47
Velvet bean (full pods) N-P-K	Jan. 12 to Jan. 22.	74	71	70	59	85	76	63	1.53	5.12	5.62
Pigeon pea (before blooming) N-P-K	Feb. 1 to Feb. 21.	56	62	61	38	69	58	45	1.40	3.62	4.13
Yaragua (N and P)	Oct. 2 to Oct. 22.	51	42	48	61	51	54	84	0.43	23.89	1.68
Merker grass (N only)	Feb. 21 to Mar. 14	55	65	55	64	58	60	62	0.87	7.13	2.17
Merker grass (N only) 1¼ plus pigeon pea (before blooming) 1	Mar. 19 to Mar. 29	51	52	48	41	63	54	63	1.04	6.98	3.94

NOTE:
Yaragua—average of 5 animals.
Merker gass + pigeon pea, Velvet bean (in full pods) — average of 6 animals.
The rest—average of 10 and 12 animals.

ALTERNATE HOST PLANTS OF THE PINK BOLLWORM, PECTINOPHORA GOSSYPIELLA (SAUND.), IN PUERTO RICO

By L. COURTNEY FIFE, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine [1, 2]

INTRODUCTION

A knowledge of the importance that alternate host plants play in the perpetuation of the pink bollworm, *Pectinophora gossypiella* (Saund.), from one cotton crop to the next is valuable in formulating methods for its control. Heretofore this problem has been little studied in Puerto Rico.

Puerto Rico is comparatively rich in Malvaceae, the only family of plants that has been found to include species attacked by this pest, 19 genera and 59 species having been recorded. Other than cotton. however, only 5 genera and 9 species of food plants of the pink bollworm are found on the Island. The importance of each of these food plants in maintaining the pink bollworm in the absence of cultivated cotton is briefly discussed in the following notes.

MONTEZUMA

Maga, *Montezuma speciosissima,* is a tree endemic to Puerto Rico. It has been planted along roadsides as an ornamental and for shade, but it is also found on waste land in mountain ranges. The tree is most abundant in the cotton-growing region on the north coast between Aguadilla and San Juan. The wood is used in making furniture, interior woodwork, musical instruments, fence posts, etc. The large. showy flowers are bright red and remain on the plant several days after opening. Every tree bears numerous seed capsules which average 1½ inches in length and 1¼ inches in diameter, and each pod contains several naked seeds.

The relation between the time of abundance of mature seed capsules on this tree and the seasons of cotton production on the north coast is shown in Figure 1. It will be noted that few or no mature seed capsules are found on this plant during June, July, August,

[1] Working in cooperation with the Puerto Rico Experiment Station of the United States Department of Agriculture.

[2] The writer is greatly indebted to Mr. José Otero, Librarian of the Insular Experiment Station, for the identification of the various plants mentioned in this publication.

and September. Buds and flowers, however, are produced in abundance during the entire year.

Counts for pink bollworm infestation were made in the fruiting forms of maga during the first week of each month from November 1936 to May 1937, inclusive. The area surveyed included most of the commercial cotton-growing districts along the north coast between Aguadilla and Camuy (43 kilometers). Large samples of pods and buds were taken about every 2½ kilometers in this area.

The results of examination of the mature seed capsules are summarized in Table 1 and graphically illustrated in Figure 1. It will be noted that the average percentage of infested seed capsules gradually decreased from 30 percent in November 1936 to 1.1 percent in May 1937. The highest percentage of infested pods was 54.3 percent, recorded in November at Camuy. Even as late as April the pod infestation averaged 10.6 percent, ranging from 2 percent at Isabela to 28 percent at Aguadilla. Also, of 100 pods examined at Camuy in March 1937, 41 percent were found infested. It will also be noted that the infestation was highest on *Montezuma speciosissima* during the dead season of cotton production, i. e., from September 30 to January 1. The mature seed capsules, however, are most numerous during the planting season. They gradually decrease in numbers and by June become very scarce. As shown in Figure 1, the infestation is carried over on these pods well into the growing period of cotton.

At Isabela, Wolcott (1936) found maga pods continuously infested from September 1931 to June 1932, the infestation ranging from 90 percent in October to 5 percent in March. He examined about two samples per month during this period and all were infested.

The results of pink bollworm infestation counts in large buds of maga from December 1936 to March 1937 on the north coast between Aguadilla and Camuy are summarized in Table 2. The average number of buds found infested was as follows: December, 16.5 percent; January, 9.3 percent; February, 4 percent; and March, 0.4 percent. The highest infestation in buds was 35.3 percent in December at Isabela. It will also be noted that buds were not so heavily infested as the pods, the ratio being about 1 to 4.

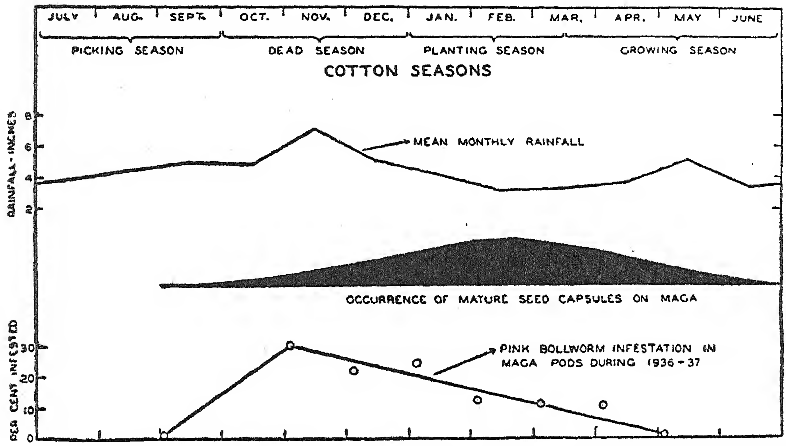

FIGURE 1.—Relation between the planting, growing, picking, and dead seasons of cotton production; mean monthly rainfall distribution; occurrence of mature seed capsules on maga, *Montezuma speciosissima;* and pink bollworm infestation in maga pods during 1936–37 in the cotton area on the north coast of Puerto Rico.

TABLE 1—PINK BOLLWORM INFESTATION IN THE MATURE SEED CAPSULES OF *Montezuma speciosissima* ON THE NORTH COAST OF PUERTO RICO BETWEEN AGUADILLA AND CAMUY FROM NOVEMBER 1936 TO MAY 1937, INCLUSIVE *

Locality		Distance from San Juan	Percentage of seed capsules infested during:						
			1936		1937				
		Kilometers	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Aguadilla		141	....	....	....	....	17.0	28.0	1.2
Aguadilla		139	48.4	24.1	39.7	15.9	0.8	8.0	6.4
Aguadilla		137	....	....	....	....	10.0	5.0	1.4
Aguadilla		135	....	....	9.1	12.3	11.0	22.0	1.1
Isabela		132	....	24.1	....	....	7.0	5.0	0
Isabela		129	....	....	23.5	7.0	4.0	10.0	3.4
Isabela		125	....	....	....	....	6.3	2.0	0
Isabela		120	31.4	8.1	17.3	31.6	12.9	9.0	....
Quebradillas		111	34.8	37.5	33.3	8.7	13.0	13.0	0
Quebradillas		109	16.7	....	....	4.8	....	....	0
Quebradillas		107	11.0	20.0	43.4	10.4	8.8	4.5	0
Camuy		102	13.3	....	7.2	9.4	8.0	6.0	0
Camuy		101	54.3	17.3	20.8	15.1	0	3.0	0
Camuy		99	....	....	....	....	41.0	22.0	....
AVERAGE		....	30.0	21.9	24.3	12.8	10.8	10.6	1.1
Number of pods Examined per sample	Average		51.6	85.2	63.4	96.6	95.8	99.1	116.1
	Max.		82	120	83	149	120	100	203
	Min.		30	37	44	48	62	88	61

(*) All seed capsules were collected and examined during the first week of each month.

TABLE 2—PINK BOLLWORM INFESTATION IN LARGE BUDS OF *Montezuma speciosissima* ON THE NORTH COAST OF PUERTO RICO BETWEEN AGUADILLA AND CAMUY FROM DECEMBER 1936 TO MARCH 1937, inclusive. *

Locality		Distance From San Juan Kilometers	Percentage of infested buds during—			
			Dec. 1936	1937		
				Jan.	Feb.	Mar.
Aguadilla		141	...	...	...	0
Aguadilla		139	...	18.5	0	0
Aguadilla		137	...	...	...	0
Aguadilla		135	...	1.4	0	0
Isabela		132	...	...	...	0
Isabela		129	...	0	0	2.0
Isabela		125	...	...	...	0
Isabela		120	35.3	9.1	11.1	3.1
Quebradillas		111	...	16.7	0	0
Quebradillas		109	7.1	...	2.7	0
Quebradillas		107	...	14.0	14.3	0
Camuy		102	...	4.5	0	0
Camuy		101	7.1	10.5	8.3	0
Camuy		99	...	...	...	0
AVERAGE		...	16.5	9.3	4.0	0.4
Number of buds examined per sample	Average		76.7	42.6	28.4	17.6
	Max		119	99	75	51
	Min		42	19	7	5

(*) All buds were examined during the first week of each month.

As many as four mature larvae have been found in one seed capsule and three in one bud. In the pods the larvae feed almost entirely inside the seeds, hollowing-out their contents. When the larvae become mature they may tunnel to the outside or remain in the seeds to pupate.

As shown also in Figure 1, the picking season on the north coast occurs during a period of heavy rainfall and the planting season during the driest period. Mr. U. C. Loftin, in an unpublished report submitted in 1931, recommended a reversal of the seasons of cotton production in this area so that the planting season would occur during the period of heaviest rainfall and the picking season during the driest period, thereby establishing uniform cotton seasons for the entire island. A further study of this problem by the writer (1937) suggested that the seasons of cotton production be adjusted so that the dead season would coincide with the period when very few seed capsules occur on maga, i. e., from May 1 to July 31 of each year. If this were done the pink bollworm would be more limited in finding suitable fruiting forms on maga in which to breed up in large numbers during the dead season between one cotton crop and the next. If such

changes were effected the planting season would also coincide with the period of greatest rainfall and the picking season with the driest period. The growers would greatly benefit by such a practice, since a reduction in the pink bollworm infestation would permit them to produce more cotton of a superior quality.

THESPESIA

Thespesia populnea (emajagüilla) is a wild tree which occurs in waste places on the lower coastal plains, particularly on the south coast between Cabo Rojo and Ponce. It has been planted along roadsides as an ornamental and for shade. Fruiting forms in all stages of development may be found on this plant during the entire year. The mature seed capsules average about 1 inch in length and about 1½ inches in diameter, and each pod contains several naked seeds.

Numerous seed capsules were examined throughout the closed season of cotton production on the north coast in 1936 and 1937. As shown in Table 3, the mature green pods were found infested from September 1936 to March 1937. During this entire period the infestation averaged 3.4 percent, the highest being 14.3 percent. *Thespesia populnea* does not, however, become infested until after the cotton has been destroyed at the end of the season. These data show that the pink bollworm will successfully maintain itself on this host plant in the absence of cotton for 4 or 5 months.

This tree has previously been reported as a host plant of *Pectinophora gossypiella* in Hawaii by Fullaway (1909) and Willard (1927), in the Virgin Islands by Loftin (1931, and in Puerto Rico by Wolcott and Seín (1931).

TABLE 3—PINK BOLLWORM INFESTATION IN THE MATURE GREEN SEED CAPSULES OF *Thespesia populnea* ON THE NORTH COAST OF PUERTO RICO FROM SEPTEMBER 1936 TO APRIL 1937, INCLUSIVE.

Locality	Date examined	Number examined	Percent infested
Isabela	Sept. 9, 1936	100	0
Isabela	Sept. 15, 1936	325	4.0
Quebradillas	Nov. 5, 1936	100	0
Isabela	Nov. 5, 1936	100	3.0
Isabela	Nov. 19, 1936	70	14.3
Aguadilla	Nov. 19, 1936	100	5.0
Isabela	Dec. 11, 1936	100	0
Isabela	Dec. 12, 1936	100	4.0
Isabela	Jan. 11, 1937	64	4.7
Isabela	Feb. 10, 1937	129	3.9
Isabela	Feb. 10, 1937	67	1.5
Isabela	Mar. 6, 1937	100	4.0
Isabela	Apr. 5, 1937	84	0

Abelmoschus

Okra, *Abelmoschus esculentus,* is cultivated quite extensively in all parts of the Island. Since pod infestations of okra as high as 50 to 90 percent have been recorded in other countries when this crop was growing adjacent to heavily infested cotton, it is considered a rather favorable host plant of the pink bollworm. Wolcott (1931) reports that even young pods may become infested when nearby cotton is infested, necessitating quarantine regulations against its exportation. Consequently, as a means of controlling the pink bollworm, it would seem logical to avoid the growing of okra during the closed season of cotton production.

Okra has also been reported as a host plant of *Pectinophora gossypiella* in Mexico by Loftin et al (1921), Ohlendorf (1926), and Rude (1932), in Egypt by Willcocks (1916), in Africa by Taylor (1936), in the Virgin Islands by Loftin (1931), and in Australia by Holdaway (1926).

Algalia, *Abelmoschus abelmoschus,* is occasionally grown in Puerto Rican gardens for its musk-scented seeds and for medicinal purposes. The large bristly seed pods average around 2¾ inches in length and 1¼ inches in diameter. Of 129 pods collected adjacent to infested cotton at Isabela, 10, or 7.8 percent, were found infested. First-instar pink bollworm larvae were artificially installed on 20 mature green seed capsules and 10, or 50 percent, became infested. One infested pod contained 11 mature larvae and 1 of the third instar. These observations indicate that the seed capsules of algalia are well adapted to the feeding habits of pink bollworm larvae.

Hibiscus

The majority of the known host plants of the pink bollworm belong to the genus *Hibiscus,* of which at least 18 different species have been reported from various countries of the world. Only three species, however, were found to be attacked by *Pectinophora gossypiella* in Puerto Rico namely, *H. trilobus, H. bifurcatus,* and *H. sabdariffa.*

Of these three species, *Hibiscus trilobus* is markedly preferred. Of 87 pods collected 3 or 4 miles from a cotton area during the dead season at Boquerón, 14, or 16.1 percent, were infested. Many pupae were found inside the pods, a few pods containing three live pupae each. The involucre completely covers the seed capsule except for a small opening at the extreme tip. Some of the emerging moths

were trapped in this enclosure and died. The seed capsules are about $1\frac{1}{2}$ inches in diameter and $1\frac{3}{4}$ inches in length, and it appears that they are well adapted to the feeding habits of this pest.

Hibiscus bifurcatus and *H. sabdariffa* were grown beside heavily infested cotton at Isabela and both became infested. In the former species 4.2 percent of the seed capsules were infested and 0.7 percent of the pods in the latter.

Hibiscus rosa-sinensis (var. Velvet Red) is a very common ornamental, grown as hedges, along roadsides, and in gardens, at all elevations. However this species rarely, if ever, produces seed capsules, although buds are produced in abundance during the entire year. Of 697 buds collected adjacent to heavily infested cotton, none was found to be infested. First-instar larvae were installed on 80 buds but none became infested.

Although *Hibiscus schizopetalus* is quite common, it rarely develops seed pods. The buds are small and not well adapted to the feeding habits of the larvae.

Both Taylor (1936) in Africa and Willcocks (1916) in Egypt report the presence of the pink bollworm in *Hibiscus cannabinus;* and one larva was taken in *H. mutabilis* by Loftin et al (1921) in Mexico. These two species are known to occur in Puerto Rico but only in limited numbers.

Of 568 seed pods of *Hibiscus brasiliensis* collected in an infested cotton-growing area over a period of several months at Boquerón, none was found infested. This plant is quite numerous on the southern coast between Boquerón and Ponce.

No species of *Hibiscus* attacked by *Pectinophora gossypiella* in Puerto Rico is sufficiently numerous to be of any importance in maintaining this pest during the closed season of cotton production.

Althaea

Although *Althaea rosea* (hollyhock) is occasionally attacked by the pink bollworm in Puerto Rico, it is not sufficiently abundant to be of any importance. Loftin, McKinney, and Hanson (1921) and Rude (1932) report it as a host plant in Mexico. and Willcocks (1916) in Egypt.

Abutilon

Quantities of seed capsules of *Abutilon hirtum* were collected repeatedly near infested cotton and placed in rearing cages for emergence. From 502 pods collected at Boquerón, 2 pink bollworm

moths emerged. From all the other collections no stage of this pest was ever recovered. The green pods are coated with a resinous secretion which might serve as a protection against certain insects.

It is interesting to note that Holdaway (1926) reports *Abutilon octocarpus* and *A. amplum* as host plants of *Pectinophora gossypiella* in West Australia and *A. indicum* in South India; McDonald (1931) records it from *A. hypoleucum* in Mexico but believes it would not survive on this host plant in the absence of domestic cotton; and King (1917) reports it from hanbuk (*Abutilon* sp.) in Africa. Britton (1924) reports the presence of *A. indicum, A. umbellatum*, and *A. commutatum* in Puerto Rico.

Miscellaneous Records

Three wild species of malvaceous plants are very common in Puerto Rico. These are *Sida cordifolia*, *Malachra capitata*, and *Malvastrum sp.* Large quantities of these plants were collected repeatedly near infested cotton and placed in rearing cages but no stages of the pink bollworm were ever found in them. However, species of both *Sida* and *Malvastrum* have been reported as host plants of the pink bollworm in other parts of the world.

Numerous seed capsules of *Pariti tiliaceum* were examined for the pink bollworm, but the results were negative. In most cases these fruiting forms were collected in cotton-growing areas heavily infested with the pink bollworm. Holdaway (1926) reports that this shrub is a primary host plant of a closely related species, *Platyedra scutigera,* in Queensland and New South Wales.

According to Hunter (1926), Cayla (1921) reports *Bombax monguba* (Bombaceae) as a host plant of *Pectinophora gossypiella* in Brazil. Numerous seed pods of a closely related species, *Ceiba pentandra*, were examined in Puerto Rico. but no stage of this pest was found in them.

Summary

The seed pods of three malvaceous plants, *Montezuma speciosissima* (maga), *Thespesia populnea* (emajagüilla), and *Abelmoschus esculentus* (okra, or guingambó) were found to be important host plants of the pink bollworm in that they provide a continuous food supply for breeding during the dead season of cotton production. Several other plant species were attacked, namely, *Abeloschus abelmoschus* (algalia), *Hibiscus sabidariffa* (vina), *Hibiscus trilobus, Hibiscus bifurcatus* (buenas tardes), *Abutilon hirtum* (buenos días),

and *Althaea rosea* (hollyhock, or varilla de San José). None of these species, however, is sufficiently numerous to be of any importance.

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A SEARCH IN THE GUIANAS AND TRINIDAD FOR PREDATORY BEETLES OF THE BAMBOO SCALES

By K. A. BARTLETT, *Associate Entomologist*, Puerto Rico Experiment Station, United States Department of Agriculture

BAMBOO SCALES ARE COMMON THROUGHOUT THE WEST INDIES AND NORTHERN SOUTH AMERICA.

Throughout the West Indies and in northern South America there are two species of scales which commonly attack bamboo, *Asterolecanium bambusae* (Bdv.) and *A. miliaris* (Bdv.). The former species generally confines its attack to the culms and larger branches, while the latter species usually attacks the leaves. In Puerto Rico both of these scales are particularly prevalent. Only one species of predatory beetle has been recorded as feeding on *A. bambusae* in Puerto Rico; Wolcott [1] records the collection of *Scymnillodes cyanescens* var. *violaceus* Sicard. S. M. Dohanian, in an unpublished report, states that he observed a number of predators feeding on bamboo scales in Trinidad. Director Lee, of the Puerto Rico Experiment Station of the United States Department of Agriculture in a trip through the West Indies and northern South America, also observed considerable numbers of predatory beetles feeding on bamboo scales.

SEARCH FOR PREDATORY BEETLES WAS MADE IN BRITISH AND DUTCH GUIANA AND IN TRINIDAD.

In conjunction with a trip to British Guiana to obtain the Amazon fly, [2] there was presented the possibility of making a search for predatory beetles of the bamboo scales. An appropriation from regular funds of the Puerto Rico Experiment Station also afforded an opportunity to visit Trinidad and Dutch Guiana in search of these predatory beetles. I wish to take this opportunity to express my thanks to L. D. Cleare, Entomologist, British Guiana Department of Agriculture, G. Stahel, Director Experiment Station, Dutch Guiana, and to Alan Pickles Entomologist Trinidad Department of Agriculture, for their cooperation in the search and collection of these predatory beetles.

[1] Wolcott, G. N. "Insectae Borinquenses". The Journal of Agriculture of the University of Puerto Rico, Vol. XX, No. 1. January 1936.
[2] A cooperative project financed by the Puerto Rico Sugar Producers Association and the Fajardo Sugar Co.

Eight Species of Predatory Beetles Were Collected and Shipped to Puerto Rico

During a 4-day stay in Trinidad, six species of predatory beetles were found feeding on the bamboo scales *A. bambusae* and *A. miliaris.* The following species were collected in the vicinity of the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, W. W. I.: *Azya trinitatis* Marsh., *Cryptognatha nodiceps* Marsh., *Delphastus* sp., *Pentilia castanea* Muls., and *Pentilia* sp. [3]

In Dutch Guiana during a 2-day search for predatory beetles, three species were found, namely *Azya* sp. probably *trintatis* and two species of *Pentilia.*[3] These collections were made at a plantation on the opposite side of the river from Paramaribo, Dutch Guiana. Collections were made from bamboo growing along the banks of drainage canals. In some cases it was necessary to collect from dugout canoes, and this factor, together with the constant danger of poisonous snakes, made collection rather difficult.

In British Guiana three species were collected, *Azya trinitatis, Pentilia castanea,* and *Pentilia* sp.[4]. In addition to the above species, which were sent to Puerto Rico, there were collected a few specimens of *Scymnillus* sp. and *Delphastus* sp. and one specimen of *Azya pontbrianti* Muls. On one occasion on bamboo planted near a sugarcane field several specimens of *Cycloneda sanguinea* (L.) were observed feeding on *A. miliaris.* The shipments of predatory beetles sent by air express to Puerto Rico are summarized in Table 1.

Table 1—A summary of the collections of adult predatory beetles in British and Dutch Guiana and Trinidad which were shipped by air express to Puerto Rico, giving location, date, species, and number shipped

Species	British Guiana Sept. 25 and Oct. 2, 1937	Dutch Guiana Sept. 4, 1937	Trinidad Aug. 4, 1937
	No. shipped	No. shipped	No. shipped
Azya trinitatis	292	...	10
Azya sp. probably *trinitatis*	...	27	...
Cryptognatha nodiceps	...	...	11
Curinus sp.	...	...	639
Delphastus sp.	...	...	536
Pentilia castanea	638	...	278
Pentilia sp. (1)	82	79	24
Pentilia sp. (2)	...	133	...
Total	1,012	239	1,498

(1) A dark brown species with red dots on wing covers.
(2) A solid dark brown species.

[3] Determinations by E. A. Chapin, U. S. National Museum.
[4] A dark brown species with red dots on wing covers.

Bamboo Scales Appeared to Be of Little Importance in the Countries Visited.

While both bamboo scales, *Asterolecanium bambusae* and *A. miliaris,* were readily found in all the countries visited, it is of importance to record that the scale attacks were confined almost entirely to a single species of bamboo, *Bambusa vulgaris* Schrad; this was particularly true of *A. bambusae* found on the culms and of comparatively slight infestation. In Puerto Rico, where natural enemies are lacking, these scales are found attacking not only the common *B. vulgaris,* but also most of the more important species of bamboo which have been recently introduced from other countries of the World.

The species of beetles collected were found in proportionate numbers to the adults shipped. Larvae of all the species collected were observed feeding on scales on both the culms and leaves. The adults were most abundant in the sunlight. It is hoped that the introduction and establishment of these beetles in Puerto Rico may result in a reduction of our bamboo scale infestations.

A DRYINID PARASITE ATTACKING *BALDULUS MAIDIS* IN PUERTO RICO

By K. A. Bartlett, *Associate Entomologist*, Puerto Rico Experiment Station, United States Department of Agriculture.

An interesting parasite of the corn leafhopper, *Baldulus maidis* (Del. and W.),[1] was observed at Mayagüez, Puerto Rico, during August 1937, by Wallace K. Bailey, Associate horticulturist at this, the Federal Experiment Station, who called it to the attention of the writer. Following observations, collections were made and material reared for determination. The parasite was found to be a new species of *Gonatopus* very near *G. bicolor* Ashm.,[3] known to attack *Baldulus maidis* in the United States. Observations were apparently made on the parasite in 1912 by T. H. Jones (1), who reared specimens of a new species of *Gonatopus* from cocoons collected on cane leaves. Wolcott (1) records the finding of *Baldulus maidis* parasitized by a blue-green strepsipteron, which might easily have been mistaken for the larval sac of this dryinid parasite.

This parasite is antlike in appearance; the adult females are wingless. The forelegs of the female are especially adapted to the catching and holding of the leafhopper while inserting an egg in the dorsal side of the abdomen. After oviposition the leafhopper is released and the parasite begins development. A wartlike protrusion develops on the abdomen of the leafhopper. This protrusion is a portion of the body of the parasite larva partially enveloped in cast skins. When the parasite larva becomes full-fed the leafhopper dies and remains attached to the under side of the leaf for at least a short period. During this time the parasite larva detaches itself from its host and spins a white, flat, oval cocoon nearby on the leaf or stalk of the plant. From this cocoon the adult parasite later on emerges.

Collections of living leafhoppers in the field showed a parasitization by *Gonatopus* of 15 percent. The effectveness of the parasite is somewhat reduced by a hyperparasite which attacks the cocoons. Specimens of this hyperparasite were reared and identified as *Ooencyrtus* n. sp.[2]

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[1] Identification by P. W. Oman, Bureau of Entomology and Plant Quarantine.
[2] Identification by A. B. Gahan, Bureau of Entomology and Plant Quarantine.

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ECOLOGICAL NOTES ON MOSQUITOES ASSOCIATED WITH BROMELIADS [1]

By George S. Tulloch
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Epiphytic bromeliads living on a variety of host plants are conspicuous elements of the flora of Puerto Rico. In the coastal plain they are found in small numbers attached to mangroves growing near the seashore or to trees growing along the rivers. They are particularly abundant in the dense forest of the mountains, occurring in such numbers as to obscure almost completely the trunks of Sierra palms and other host trees. Conditions favorable for their development appear to be heavy rainfall, high temperature, and protection from direct sunlight. Perhaps the most conspicuous bromeliad growing in the mountainous region of Puerto Rico is *Catopsis berteroniana.*

The epiphytic bromeliad is an herbaceous plant with a shortened stem bearing a rosette of leaves and a panicle of flowers. Each narrow, lanceolate leaf has a sheath which surrounds the stem, and forms, with the sheaths of the other leaves of the rosette, a basin in which water and organic material collect. Special hairs, which are developed on the inner surface of the sheath, absorb water and dissolved substances for the plant. In the basins of these plants aquatic conditions suitable for the development of mosquitoes, snails, nematodes, midges, crustaceans, rotifers, etc., are found.

In the mountains of Puerto Rico large numbers of mosquitoes are found in bromeliads. Here the heavy annual rainfall (over 100 inches) insures the presence of water in the leaf basins at all times. The water usually is yellowish or brownish, the coloration being caused by the decomposition of leaves and other organic materials which are washed into the bromeliads during the heavy rains. Certain observations pertaining to the temperature and pH value of the water, as well as to the species encountered, are summarized in Table 1.

The range of temperature of the water in bromeliads containing mosquito larvae was 65°–81° F. The temperature was usually

[1] These investigations were carried on in cooperation with the Federal Experiment Station at Mayagüez, Puerto Rico, under the technical direction of the Division of Insects Affecting Man and Animals, with special funds available to the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, for studies on insects of Puerto Rico.

less than 75° F. The higher temperatures are not common, as they are found only when the plants are exposed directly to the sun. The prevailing low temperatures of water in bromeliads are responsible to some degree for the slower rate of development of these mosquitoes.

The waters in all bromeliads examined were acid, the range of pH value being 3.8–6.6. The only sources of water in these plants are rain waters or dew, which has a pH value of 7. The shift to the acid condition apparently is a result of the decomposition of the organic materials present in the leaf bases. Possibly humic acids are liberated. Although certain protozoa, rotifers, and crustaceans have been cited [2] living in waters with a pH value as low as 3.2–3.8, no similar records for insects are available. Mosquito larvae have been taken in water with a pH range of 5.8–8.6 [3], but no records of insects developing in waters more acid than this are available. The bromeliads are likewise living in an acid environment since they utilize the water and dissolved materials contained in the leaf bases. The method by which a protoplasmic system adapts itself to a medium that is strongly acid or alkaline is not completely understood. The theory that hydroxyl and hydrogen ions penetrate membranes slowly and are neutralized by buffers within the protoplasm appears to be as adequate as any.

The species of mosquito larvae that were taken from bromeliads were *Wyeomyia mitchellii* Theobald, *Culex americanus* (Neveu-Lemaire), *Megarhinus portoricensis* Roeder, and *Corethrella appendiculata* Grabham. The larvae of *W. mitchellii* are bright yellow and have slightly flattened bodies. Much of their time is spent feeding over or resting on the debris at the bottom of the water. They come to the surface for air less often than the majority of mosquito larvae. The larvae of *C. americanus* have bodies well provided with tufts of bristles. They are usually found at the surface and descend to feed for only brief intervals. The larvae of *C. appendiculata* are small, active forms which were always associated with one or both of the above species. *M. portoricensis* was taken only once in bromeliads at Maricao, P. R., August 1935, at an elevation of 2,000 feet. This record is not included in table 1, as temperature and pH values were not taken.

[2] Heilbrunn, L. V. An Outline of General Physiology, p. 381. Philadelphia. 1937.
[3] Chapman, R. N. Animal Ecology, p. 151. New York. 1931.

TABLE 1—COLLECTION RECORDS OF MOSQUITOES BREEDING IN BROMELIADS IN PUERTO RICO, 1936.

Date	Locality	Elevation feet	Collection No.	Temperature of water oF.	pH of water	Species present
January 28	Maricao National Forest	3,000	1	73	6.5	*Culex americanus*
			2	74	6.4	*C. americanus, Corethrella appendiculata*
			3	77	5.8	*C. americanus, Wyeomyia mitchellii*
			4	71	6.4	*C. americanus, C. appendiculata*
			5	73	6.0	*W. mitchellii*
			6	72	6.4	*W. mitchellii, C. americanus*
			7	71	6.3	*C. americanus*
			8	73	6.6	*C. americanus*
			9	72	6.0	*W. mitchellii*
			10	71	6.4	*W. mitchellii, C. americanus*
March 24	Luquillo National Forest	3,000	1	68	5.0	*C. americanus, C. appendiculata*
			2	68	5.5	*C. americanus, C. appendiculata*
			3	68	4.0	*C. americanus, W. mitchellii*
			4	68	3.8	*C. americanus*
			5	66	4.5	*C. americanus*
			6	66	4.5	*C. americanus*
			7	66	4.3	*C. americanus*
			8	66	3.8	*C. americanus*
			9	66	3.8	*C. americanus*
			10	67	4.3	*C. americanus, W. mitchellii*
May 5	Maricao National Forest	3,000	1	81	5.5	*W. mitchellii, C. appendiculata*
			2	77	5.0	*C. americanus*
			3	78	5.5	*C. americanus, W. mitchellii*
May 21	Luquillo National Forest (Bretton Peak)	3,500	1a	65	5.5	*C. americanus, W. mitchellii*
			b	66	6.0	*C. americanus*
			c	66	4.5	*C. americanus*
			d	66	4.7	*C. americanus, W. mitchellii*
			e	66	4.5	*C. americanus, W. mitchellii*
			f	67	5.6	*C. americanus*
			g	67	6.0	*C. americanus*
			h	67	4.5	*C. americanus*
			i	66	4.8	*C. americanus, W. mitchellii*
			j	66	5.0	*C. americanus*
May 21	Luquillo National Forest	3,000	2a	68	5.5	*C. americanus*
			b	68	6.0	*C. americanus*
			c	68	6.0	*C. americanus*

THE BIRDS OF SABA

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During the course of a leave of absence granted by the Hon. Board of Trustees of the University of Puerto Rico, the author spent the first seven months of 1937 making collections and continuing investigations already begun on the fauna of the Lesser Antilles.

One of the first islands to be visited was Saba, on which the author, accompanied by Mr. Gustavo Biaggi as assistant, spent the period from January 23 to February 4.

Saba is merely a solitary extinct and rugged volcano arising precipitously from the sea in the northern Lesser Antilles, at a distance of 17 miles northwest of St. Eustatius, 21 miles northwest of St. Kitts, and 26 miles southwest of St. Martin. It is a Dutch possession, and is regarded as a dependency of the colony of Curaçao, though it is approximately 500 miles from the island of that name. Although it is a Dutch possession, English is the only language spoken by the residents, and United States currency is used for all business except dealings with the government.

The only ordinary means of reaching the island is by means of the small Dutch mail steamer "Baralt" which makes two round trips a month between Curaçao, St. Thomas, St. Kitts, and the three small Dutch islands in the northern Lesser Antilles (Saba, the Dutch port of St. Martin, and St. Eustatius). The landing at Saba is very difficult, as there is no harbor and the small boat which takes passengers ashore from the steamer merely lands them on the rocks on a beach in an exposed position on the southern coast. There one should count on receiving a ducking from the spray and waves as part of the ordinary landing procedure. A complaining passenger was very simply rebuked by the stolid boatman with the admonition "This is Saba". From the landing place, (where the only building is a small customs house), a pathway in large part cut as steps in the solid rock of the mountainside leads up to the town known as The Bottom, occupying an extinct volcanic crater at about 900 feet elevation. This is the seat of government, and here resides the "Gezaghebber", or district governor. After obtaining permission from him to make our collections, we continued on up the moun-

tain pathway to another village of about equal size known as Windwardside, at an elevation of about 2000 feet on a shoulder on the eastern slope of the mountain. Here our friend, Mr. Stanley Johnson, had made arrangements for us to stay, there being no regular hotel or boarding accomodations on the island. This was the center of our activities during our entire stay.

The rugged volcano which comprises Saba attains a height of 2820 feet, according to the British Admiralty charts. Its upper parts are known locally as "the Mountain", and are clothed by an almost pure stand of tree ferns extending to the very summit. At that point there is a rather small extinct crater in which bananas are planted to protect them from the wind. Some large boulders have been thrown up on the rim by volcanic action these constituting the extreme highest points of the island.

From the higher parts of the mountain there extend down to the sea a number of steep walled, deep, rugged ravines known locally as "guts". These are filled with a dense semi-xerophytic growth of brush and small trees; and together with the mountain top are the best places to find birds. The rest of the mountain side (and practically all of Saba is mountain side) has rather sparse vegetation due to its exposed position and the cultivations of the residents. In the northwestern part of the island there is an abandoned copper mine, comprising various caves and tunnels. Here many bats occur. Iguanas and snakes abound in the guts.

Previous to our visit I find record of only two ornithological collectors who had visited the island. F. A. Ober visited Saba approximately sixty years ago, and apparently collected but very few birds (among them the type of *Geotrygon sabae*). No report was written on them, but reference to a few specimens in the U. S. National Museum secured by him is made by Ridgway (U. S. Nat. Mus. Bull. 50). James Bond, of the Academy of Natural Sciences of Philadelphia, made a short visit to the island in November and December, 1928 and collected a few birds which are now in the collections of that institution. He published no report on his work there, but reference is made to a few Saba birds in his "Birds of the West Indies".

I have been able to find published records of 19 species of birds (2 of them doubtful) from Saba prior to our visit. Eight forms were added to the list as a result of our work, bringing the list of birds known from Saba up to 28 forms (including three which are doubtful). A few records obtained on a very short visit to

Saba in December, 1927 while travelling on a sailing vessel en route to other islands are included. Doubtless this list could be increased considerably by long continued observations, chiefly through the addition of migratory birds.

In conclusion I must express a debt of gratitude to the many people in Saba who most willingly and whole-heartedly assisted us in our work. Without the kindly cooperation of De Plv. Gezaghebber it would have been impossible for us to obtain permission to collect in a place where this is now difficult to obtain. To Mr. H. Stanley Johnson of Windwardside we are especially indebted for making all the physical arrangements for our stay and for the transportation of our luggage and equipment, and for many other favors shown during our visit. Mr. J. Lambert Johnson, a local hunter who knows every foot of his native island, and who is possessed of unbounded energy, was of special assistance due to his knowledge of the island and its birds. Without his aid our collections would have been much poorer. The greater part of the population of Windwardside and nearby country willingly helped in every way that they could, and it is a matter of regret that space forbids mention of more of these good people who treated us with such universal genuine hospitality and willing helpfulness as is rarely found.

An annotated list of the birds known from Saba follows:

Puffinus lherminieri lherminieri Lesson
Audubon's Shearwater
Wedrigo

An adult male and an egg taken from a hole in the rocks at Hell's Gate (altitude about 2,000 feet) on January 27 were brought to me. The egg, which was fresh, was white, and measured 52×38.8 millimeters. The bird had the iris dark brown; bill bluish slate, black at the tip; legs and feet bluish slate anteriorly, the backs of the tarsi and the soles being black. The species was said to nest commonly on the higher parts of the island.

Phaëthon aethereus mesonauta Peters
Red-billed Tropic-Bird
White Bird

There is a rather large nesting colony of this species on the Booby Hill Cliffs. At the time of our visit most of the birds had downy young, and it proved possible to find but two eggs, both

rather heavily incubated. Local boys managed to capture considerable numbers of both adult and young birds alive. Of these we preserved three adult males one adult female, and two downy young as specimens. The adults had the iris dark brown; bill bright orange red; legs, base of toes and webs light bluish tinged with yellow in parts; tips of toes black. The downy young had the iris brown; bill, legs, and basal part of feet bluish gray slightly tinged with yellow; tips of feet and webs black.

The two eggs collected on January 29 were so completely covered with brown, red and bluish speckling as to appear like earth. They measured 58.8×46.4 and 63.3×43.5 millimeters.

We were told that these birds frequent the vicinity of Booby Hill Cliffs during the entire year. On December 20, 1927 I observed one ot sea about 20 miles north of Saba. The species has not been previously recorded from Saba.

[*Phaëthon lepturus catesbyi* Brandt.

Yellow-billed Tropic-Bird.

Bond (Birds of the West Indies, p. 8) states that he observed this species at Saba, but I regard the record as somewhat doubtful in view of the facts that no specimens were taken, and that the Red-billed bird is certainly the common if not the only nesting species of the island.]

Sula leucogaster leucogaster (Boddaert)

Booby

On December 20, 1927 three were observed at sea some miles to the north of Saba.

[*Dendrocygna autumnalis autumnalis* (Linnaeus).

Black-bellied Tree-Duck

There is an extremely doubtful record by Bond (Birds of the West Indies, p. 48) who merely lists "Saba?", with no explanation. among the islands from which the species is recorded.]

Buteo jamaicensis jamaicensis (Gmelin)

West Indian Red-tailed Hawk.

Chicken Hawk or Macaw

Seen regularly soaring over the higher parts of the island, but oddly all specimens noted were immature examples which had not yet attained the red tail. One of these, a male, was shot on the

top of the mountain on January 30. It is remarkable for being smaller than any of six specimens of this race from Hispaniola and Puerto Rico in my collection. It exhibits the following measurements: Length (in flesh) 473; extent 1,109; wing 317; tail 188; culmen from base 45.7; culmen from cere 25.1; tarsus 76.3 millimeters. Bond obtained a specimen in 1929, but unfortunately it was apparently lost before measurements could be made of it.

The stomach of the specimen collected in 1937 contained a large rat.

Falco sparverius caribaearum Gmelin

Antillean Sparrow Hawk

Killi-killi

Rather locally distributed; observed at Windwardside, on the Mountain, and at the Sulphur Mine. Two pairs were collected. The stomachs of one pair were filled with large yellowish brown spiders, while those of the other pair contained exclusively crickets.

Sterna fuscata fuscata Linnaeus

Sooty Tern

On December 20, 1927 a flock of 25 was observed feeding at sea some twenty miles north of Saba.

Zenaida aurita aurita (Temminck)

Martinique Dove

Ridgway records an adult male from Saba.

Zenaida aurita zenaida (Bonaparte)

Zenaida Dove

Mountain Dove

Fairly common; noted from sea level to about 2,000 feet. A male collected in Spring Bay Gut on January 27 unquestionably represents this race.

Upon examination of the material from the northern Lesser Antilles in my collection I find it impossible to agree with Wetmore (Journ. Agric. Univ. P. R., 21, 1937, p. 11) in his statement that *zenaida* and *aurita* are distinct species, confined respectively to the Greater and Lesser Antilles. In addition to the specimen from Saba,

I have one from Antigua which is typical *zenaida*. These specimens from Montserrat are more or less intermediate, one being closer to *zenaida* and two to *aurita*. Single specimens from St. Martin. St. Eustatius, and St. Kitts are *aurita* without doubt. During a few hours spent on St. Martin on January 20, 1937 I had the opportunity of observing 9 captive birds, all said to have been obtained on St. Martin. Of these two were typical *zenaida*, three were typical *aurita*, and four were intermediate.

The stomach of the bird collected on Saba was filled with seeds, some leguminous, and some unidentified hard, round black seeds.

Columbigallina passerina nigrirostris Danforth

St. Kitts Ground Dove

Six were observed, and a male was collected at Spring Bay on January 27. Its bill was entirely dusky brown.

Oreopeleia mystacea mystacea (Temminck)

Bridled Quail-Dove

Wood Hen

This bird is rather rare, being found in the brush-grown guts which run down the mountain side in Saba. Here the bird is very difficult to obtain, the bird's shyness, the rugged topography, and the dense brush making it difficult to approach within gunshot of a bird once it is heard calling. After much effort three birds (two males and a female) were obtained at Hell's Gate Gut, Island Gut, and Spring Bay Gut. These specimens differ in nowise from specimens from the islands of St. Kitts to St. Lucia. As I have shown in the Proceedings of the Biological Society of Washington, May 19, 1938, p. 73 Riley's description of *Geotrygon sabae* was evidently based on an immature bird which he mistook for an adult, and consequently this name should be regarded as a synonym of *Oreopeleia m. mystacea*.

An adult male collected in Hell's Gate Gut on January 28, 1937 had the iris orange; the bill rose red at the base and whitish at the tip; the legs and feet of a pinkish flesh color, the claws light slate.

The three stomachs contained seeds 68.3 per cent (mostly of an unidentified hard, round black variety); leaves 5 per cent, and fragments of some starchy root with a hairy epidermis, 26.7 per cent.

Sericotes holosericeus holosericeus (Linnaeus)

Blue-breasted Hummingbird

Not common. A few were observed at Windwardside, Spring Bay, and on the Mountain. A male was collected at Spring Bay on January 26.

Orthorhynchus cristatus exilis (Gmelin)

Gilt-crested Hummingbird

The commonest of the hummingbirds in Saba, but still scarcely abundant. More were observed near the summit of the Mountain (where a male was collected on January 30) than elsewhere.

Eulampis jugularis (Linnaeus)

Garnet-throated Hummingbird

Half a dozen were observed in the tree fern forest and banana plantation at the summit of the Mountain on January 30. The stomach of a female collected contained exclusively small spiders.

[*Tyrannus dominicensis vorax* Vieillot.

Large-billed Kingbird.

Woodpecker.

A bird known locally as the "Woodpecker", which answers the description of this bird, and is said to perch on the telephone wires and sally forth after insects is said to occur on Saba only during the summer months. No specimens from Saba have been recorded, so the species is listed hypothetically.]

Elaenia martinica riisii Sclater

Riise's Elaenia

Apparently very scarce on Saba, only three being observed during the course of our visit, and residents of the island knew no name for it. A silent female was collected deep in the ravine of Spring Bay Gut on January 27, and another female, also silent, in deep brushy woods at Spring Bay the next day, and one was heard singing on the top of the Mountain on January 30. As I have already demonstrated (Journal of the Barbados Museum and Historical Society, Vol. S, May, 1938, p. 123), these specimens exhibit characteristics (particularly those of size) of *riisii* rather than of typical *martinica*. The measurements of a male from Saba given by Ridgway (U.S.N.M. Bull. 50, 1907, p. 427) also agree best with *riisii*.

The first stomach contained two berries. and the second some hard, round, black seeds.

Cinclocerthia ruficauda pavida Ridgway
St. Kitts Trembler
Trembling Thrush

This bird was found only in the tree fern growths on the higher parts of the mountain, and even there it is not very common. It is said to nest in holes in the trunks of rotting tree ferns, and to lay blue eggs. A male was collected in Island Gut on January 28, a male near the top of the Mountain on January 29, and a female at the same place the next day. 90 per cent of the contents of their stomachs consisted of land snails which were identified by Dr. Paul Bartsch as *Helicina fasciata* Lamarck. Coleoptera formed 7 per cent, and other insects 3 per cent.

Specimens of *C.r. pavida* from Saba and Montserrat in my collection are much more rufescent above, and to some extent below, than *C.r. tenebrosa* from St. Vincent.

Two males from Saba measure: Wing 101.4–103 (102.2); tail 84–87.1 (85.5); culmen from base 34.9–38.5 (36.7); tarsus 29.2–29.4 (29.3). One female measures, wing 99.8; tail 88.3; culmen from base (broken, but it is over 40); tarsus 30.8 millimeters.

An adult male collected in Island Gut on January 28, 1937 had the iris bright orange yellow; bill black; legs and feet yellowish brown, the soles tinged with yellow. and the claws grayish brown.

Margarops fuscatus fuscatus (Vieillot)
Pearly-eyed Thrasher
Thrush

This is undoubtedly the most common bird on Saba. frequenting all wooded and brushy regions, from which it calls with great persistency.

Four specimens were collected, three at Spring Bay and one on the top of the Mountain. These appear to represent typical *fuscatus*, but the races of this species are very poorly marked, making identification of specimens from islands near where the ranges of *fuscatus* and *densirostris* meet at times somewhat problematical.

The four stomachs contained an *Anolis* lizard, 6.2%; lepidopterous larvae 10%; insects 1.3%; berries 45%; drupes 16.2%; hard, round, black seeds 21.3%.

Allenia fusca (P.L.S. Müller)
Scaly-breasted Thrasher
Thrush; Black-billed Thrush

Six were observed on a wooded hillside near Windwardside known as "The Level" (due to its top being so much flatter than most of the land on this rugged island), and one at Spring Bay. At the former locality two males were collected on February 1. The iris of one of these was bright yellow; its bill black; its legs and feet dusky slate, claws dusky, soles yellow. One stomach contained berries and the other drupes.

Vireo calidris calidris (Linnaeus)
Jamaican Vireo

Ridgway (U.S.N.M. Bull. 50, III, 1904, p. 138) refers a female Vireo from Saba to this form. As this species is usually either a migrant or summer resident in the West Indies, none were found at the time of our visit.

Coereba bartholemica (Sparrmann)
St. Barts Honey Creeper
Yellow-breast

Common, but not so abundant as honey creepers in most islands. Two males were collected. Both have considerable white in the frontal region. They measure: wing 61.3–61.8 (61.65); tail 40.4–42; (41.2); culmen from base 16.5–17.7 (17.1); tarsus 17.8–17.8 millimeters. Their stomachs contained insects 50 per cent (small Coleoptera 25 per cent); and small seeds (mostly soft), 50 per cent. One stomach contained a large piece of gravel and several fine grains of sand, very remarkable to find in this typical, diminutive, weak Coerebine stomach.

Compsothlypis americana pusilla (Wilson)
Northern Parula Warbler

A male was collected at Spring Bay on January 27. Previously recorded by Bond.

Dendroica discolor discolor (Vieillot)
Northern Prairie Warbler

Two were observed, and a female collected, at Spring Bay on January 26. Another was seen on January 28. Not previously recorded from the island.

Setophaga ruticilla (Linnaeus)

American Redstart

An apparent female was collected at Spring Bay on January 28. Its stomach contained a moth, Coleoptera, and other insects. Not previously recorded from the island.

Tanagra flavifrons flavifrons (Sparrmann)

Green Euphonia

On February 1 a pair was observed in Spring Bay Gut. kept so continually on the move on the densely wooded preci ravine sides, usually managing to keep on the opposite wall ravine to their pursuer, that it proved impossible to collect This constitutes a new record for the island.

Tiaris bicolor omissa Jardine

Carib Grassquit

Tobacco Seed

Common at Spring Bay, Windwardside, and the lower parts the mountain. The stomachs of a pair collected contained sm seeds with the addition of sand for grinding purposes.

Loxigilla noctis coryi (Ridgway)

St. Eustatius Bullfinch

Robin

Common at the top of the Mountain rare on the rest of the island, where observed on a few occasions at Spring Bay and Windwardside. Four adult males, an immature male, and an immature (?) female were collected. These agree well with specimens of *coryi* from other localities. Their measurements are as follows: 4 adult males, wing 68.1–69.6 (69.) ; tail 51.2–53 (52.3) ; culmen from base 15.6–16.2 (15.9) ; tarsus 19–20.2 (19.65). 1 immature male, wing 63.9; tail 45.6; culmen from base 16; tarsus 19.1. 1 immature? female, wing 57.2; culmen from base 16; tarsus 18.5 millimeters.

Five stomachs examined contained seeds 80 per cent, and berries 20 per cent, and all had sand or gravel in addition for grinding purposes.

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